AD-A065 602 D'APPOLONIA CONSULTING ENGINEERS INC PITTSBURGH PA F/G 13/2
NATIONAL DAM INSPECTION PROGRAM. LOWER KITTANNING DAM (NDI-529)--ETC(U)
SEP 78 DACW31-78-C-0049
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Contract No. DACW31-78-C-0049

National Dam Inspection Program.

Lower Kittanning Dam (NDI-529), Susquehanna River Basin, Burgoon Run, Blair County, Pennsylvania. Phase I Inspection Report.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: Lower Kittanning Dam (Impounding Reservoir)
STATE LOCATED: Pennsylvania
COUNTY: Blair
STREAM: Burgoon Run, secondary tributary of Beaverdam Branch of the Juniata River
DATE OF INSPECTION: August 8 and 16, 1978

ASSESSMENT: Based on the evaluation of the conditions as they existed on the dates of inspection and as revealed by visual observations, the condition of the Lower Kittanning Dam is assessed to be poor and requires further investigation.

A depression observed on the upstream face of the dam about 300 feet from the spillway is considered to represent a potentially hazardous condition which may threaten the integrity of the dam. However, the condition is not considered to be an imminent hazard because the lake level on the date of inspection was below the observed depression.

It is recommended that the lake level be maintained at a level not higher than 15 feet below the crest of the dam until the condition is investigated and evaluated by a professional engineer and any necessary measures are implemented.

The outlet pipe through the embankment is controlled by downstream valves. Therefore, the pipe is always under pressure. It is recommended that the owner evaluate the structural integrity of the pipe through the embankment and develop means for upstream flow control on the pipe.

The reservoir is essentially an offstream reservoir. Normal flow from the watershed is diverted around the reservoir, and the reservoir receives controlled inflow. However, when the capacity of the diversion channel is exceeded, flow into the reservoir is uncontrolled. It is estimated that at 28 percent probable maximum flood (PMF), inflow into the reservoir would equal the discharge capacity of the spillway discharge channel of the dam.

The spillway capacity is classified to be "seriously inadequate" (28 percent PMF), because it is estimated that overtopping would result in failure of the dam and damage potential would be significantly higher from that which would exist prior to overtopping.

However, since the spillway capacity was determined based on the Corps of Engineers' approximate analysis procedure, it is recommended that the owner reevaluate the spillway capacity using more accurate analysis techniques.

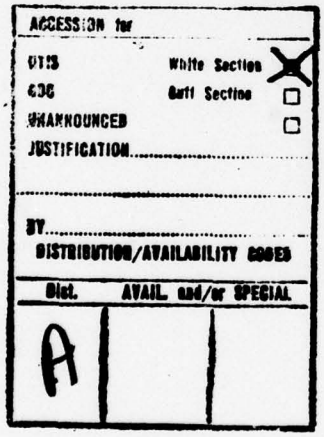
It is further recommended that the owner provide around-the-clock surveillance during unusually heavy runoff to detect possible problems and develop a formal warning system to alert the downstream residents in the event of an emergency.

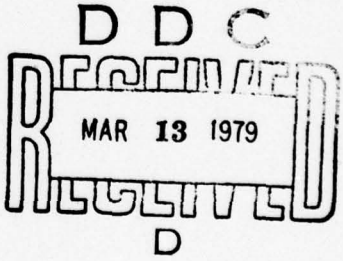
Lawrence D. Andersen, P.E.
Vice President

APPROVED BY:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

28 Sep 78





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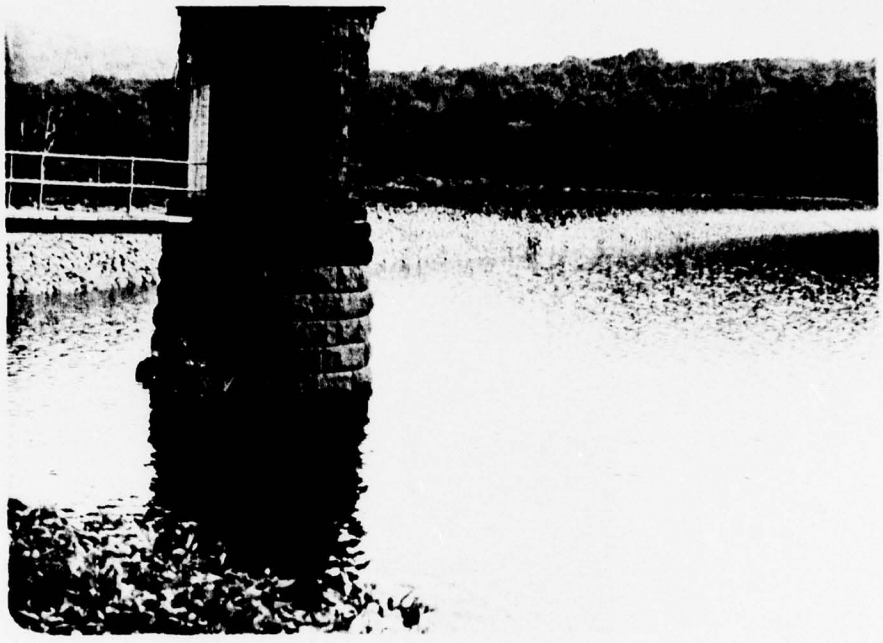
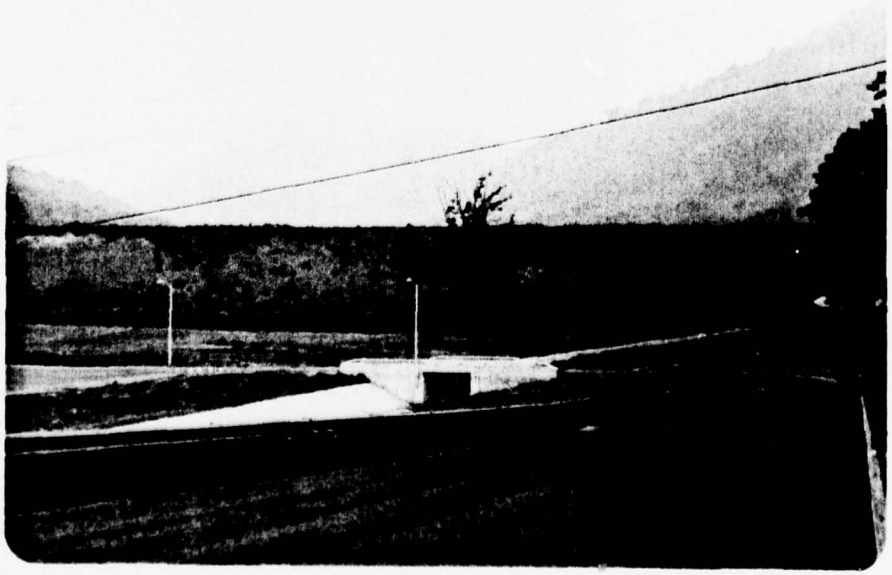
LOWER KITTANNING DAM
NDI I.D. NO. 529
AUGUST 9, 1978



Upstream Face



Downstream Face

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
LOWER KITTANNING DAM
NDI I.D. NO. 529
DER I.D. NO. 7-14

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. The dam consists of an earth embankment 1000 feet long and with a maximum height of 60 feet from the downstream toe. The dam forms an essentially offstream reservoir. A 20-foot-wide trapezoidal channel located along the north shoreline and abutment of the reservoir diverts the normal flow of Burgoon Run past the reservoir. The reservoir receives normal flow from the discharge of the primary spillway of Upper Kittanning Reservoir upstream, which in turn receives controlled inflow from the diversion channel. The Lower Kittanning Dam reservoir can also be fed through intake structures along the diversion channel.

The reservoir has a primary and emergency spillway which discharges into a common discharge channel located on the left abutment. This channel also constitues an overflow section for the diversion channel, which is diverted into a nine-foot-diameter tunnel at the left abutment of the dam.

Both of the spillways of the dam are located on the dike along the left shoreline of the reservoir between the diversion channel and the reservoir. A 25-foot-wide ogee weir at a level five feet below the crest of the dam constitutes the primary spillway for the dam. A 100-foot-wide broad-crested overflow section at a level four feet below the crest of the dam forms the emergency spillway for the reservoir.

As they presently exist, the outlet works for the dam consist of a 36-inch cast-iron combined blow-off and supply line located through the embankment near the left abutment. Flow from this pipe is controlled by two valves located at a valve chamber at the downstream toe of the dam. The valves at an intake tower near the left abutment have been dismantled and the tower is no longer in use. The 36-inch pipe constitutes the emergency drawdown facility for the reservoir.

b. Location. Lower Kittanning Dam, which is also known as Impounding Reservoir, is located in Burgoon Run Valley, about 3500 feet downstream from the tunnels under the Penn-Central Railroad Horseshoe Curve, in Logan Township, Blair County, Pennsylvania. The dam is the middle reservoir in a series of three reservoirs in Burgoon Valley and is located about three miles upstream from the city line of Altoona, (Plate 1).

The normal runoff from the Burgoon Run watershed is diverted by a channel and bypasses the reservoir (Plate 2). The inflow into the reservoir would be discharged through the primary and emergency spillways and flow into the Lake Altoona Dam reservoir, which is located about 3000 feet downstream.

It is estimated that a failure of this dam or the upstream reservoir during a flood would result in failure of the downstream reservoir and combined discharge would cause large loss of life and property damage in Altoona and further downstream.

c. Size Classification. Intermediate (based on 60-foot height).

d. Hazard Classification. High.

e. Ownership. City of Altoona (address: Mr. William L. Cochran, Director, Water, Parks and Public Property, City of Altoona, Altoona, Pennsylvania 16601).

f. Purpose of Dam. Water supply.

g. Design and Construction History. Very limited information is available on the design and construction of the dam. Available information suggests that it was designed in the early 1890s (one design drawing is dated 1892 (Plate 3) by Mr. C. W. Knight of Rome, New York. The dam was completed in 1898.

h. Normal Operating Procedures. The reservoir would be normally maintained at the level of the primary spillway, leaving five feet of freeboard to the top of the dam. Inflow occurring when the reservoir is at or above the primary spillway crest level would be discharged through the primary spillway.

1.3 Pertinent Data

a. Drainage Area (square miles) - 0.4 (direct); 9.8 (diversion channel); 10.1 (total watershed area).

b. Discharge at Dam Site (cfs)

Maximum known flood at dam site - Unknown
Warm water outlet at pool elevation - N/A
Diversion tunnel low pool outlet at pool elevation - N/A
Diversion tunnel outlet at pool elevation - N/A
Gated spillway capacity at pool elevation - N/A
Gated spillway capacity at maximum pool elevation - N/A
Ungated spillway capacity at maximum pool elevation - 950 (primary) at Elevation 1440
Total spillway capacity at maximum pool elevation - 2900 at Elevation 1440

c. Elevation (USGS Datum) (feet)

Top of dam - 1440
Maximum pool-design surcharge - 1436 (emergency spillway crest)
Full flood control pool - N/A
Recreation pool (normal pool) - 1435
Spillway crest - 1435
Upstream portal invert diversion tunnel - N/A
Downstream portal invert diversion tunnel - N/A
Streambed at center line of dam - 1375 (estimated)
Maximum tailwater - Unknown

d. Reservoir (feet)

Length of maximum pool - 2200 at Elevation 1440
Length of recreation pool (normal pool) - 2000 at Elevation 1435
Length of flood control pool - N/A

e. Storage (acre-feet)

Recreation pool (normal) - 1120 at Elevation 1435
Flood control pool - N/A
Design surcharge (maximum) - 1420 at Elevation 1440
Top of Dam - 1420 at Elevation 1440

f. Reservoir Surface (acres)

Top of dam - 60 (estimated at Elevation 1440)
Maximum pool - 45 at Elevation 1436 (emergency spillway)

Flood control pool - N/A
Recreation pool (normal) - 41 at Elevation 1435
Spillway crest - 41 at Elevation 1435

g. Dam

Type - Earth
Length - 1000 feet
Height - 60 feet
Top width - 18 feet
Side slopes - 2H:1V (upstream); 1.5H:1V (downstream)
Zoning - Unknown
Impervious core - Unknown
Cutoff - Unknown
Grout curtain - No

h. Diversion and Regulating Tunnel

Type - 36-inch-diameter cast iron
Length - 200+ feet
Closure - Valve
Access - Valves at the valve house near the toe of the dam
Regulating facilities - Valve

i. Spillway

	Primary	Emergency
Type -	Ogee concrete weir	Broad-crested weir
Length -	25	100
Crest Elevation -	1435	1436
Gate -	No	No
Upstream channel -	Lake	Lake
Downstream channel -	Masonry	Masonry

SECTION 2
ENGINEERING DATA

2.1 Design

a. Data Available

(1) Hydrology and Hydraulics. No design data were found relative to the hydrology and hydraulics for the dam. A report prepared by Hazen, Whipple and Fuller Consulting Engineers of New York, New York, dated May 27, 1921, summarizes the design capacity of the diversion channel.

(2) Embankment. Limited design drawings were available in the owner's files.

(3) Appurtenant Structures. Limited design drawings were available in the owner's files.

b. Design Features

(1) Embankment. A review of design drawings and the correspondence files for the dam show the following main features of the project:

a. As designed, the dam is a zoned embankment consisting of "select material" in the upstream zone and a "coarse material" in the downstream zone (Plate 3). An approximately 20-foot-deep, 16-foot-wide "puddle clay" cutoff trench extends along the entire length of the dam (Plates 3 and 4).

b. The embankment was designed to have a two to one (horizontal to vertical) slope on the upstream face and 1.5 to 1 slope on the downstream face (Plate 4). Both the downstream and the upstream faces were protected by riprap.

c. No reference to a subsurface investigation was found. A design drawing (Plate 4) indicates that the cutoff trench was extended to the top of rock which is classified as "red and gray" shale.

(2) Appurtenant Structures. The appurtenant structures consist of the uncontrolled primary spillways and outlet works (Plates 5 and 6). The primary and emergency spillways for the dam are located on the dike along the left shoreline of the reservoir that separates the

diversion channel and the reservoir. A 25-foot-wide ogee crested weir at a level of five feet below the crest of the dam constitutes the primary spillway for the dam. A 100-foot-wide, broad-crested overflow section which is located immediately upstream of the primary spillway forms the emergency spillway for the dam. The crest of the emergency spillway is located at a level four feet below the crest of the dam. The outlet works for the dam consist of a 36-inch cast-iron combined blow-off and supply line located through the embankment near the left abutment. Flow from this pipe is controlled by two valves located at the toe of the embankment near the left abutment.

c. Design Data

(1) Hydrology and Hydraulics. The 1921 report by Hazen et al., indicates that the capacity of the primary and emergency spillways is 600 cfs and 1000 cfs, respectively.

(2) Embankment. No data are available on the design of the dam.

(3) Appurtenant Structures. No design data are available on the appurtenant structures.

2.2 Construction. Very limited information is available on the construction of the dam. Available information indicates that Mr. C. W. Knight, the designer of the dam, supervised the construction.

2.3 Operation. As reported by the city maintenance personnel, no formal operating procedures exist for the dam. When inflow to the reservoir exceeds the supply water take-off, the pool would normally be maintained at the crest level of the uncontrolled primary spillway. The blow-off pipe is controlled by a valve located at the toe of the dam.

2.4 Other Investigations. Available information includes the following two investigation reports entitled, Altoona Water Works Report on Spillway and Flood Channels, dated May 27, 1921, by Mr. Allen Hazen, Hazen, Whipple and Fuller Consulting Engineers, New York, New York; and a letter report addressed to the Water Supply Commission of Pennsylvania dated October 4, 1920, by Mr. Arthur E. Morgan, The Morgan Engineering Company, Dayton, Ohio.

2.5 Evaluation

a. Availability. The available information was obtained from the owner's and PennDER's files.

b. Adequacy

(1) Hydrology and Hydraulics. Available information includes the design capacity of the spillways.

(2) Embankment. The available information consists of a limited number of construction drawings. No quantitative geotechnical information is available to aid in the assessment of the adequacy of the design.

(3) Appurtenant Structures. Very limited information is available on the design of the outlet works. Plate 6 shows the arrangement of the blow-off and the supply line through the embankment. No information is available on the structural details of the pipes through the embankment, such as whether concrete encasement was used.

c. Operating Records. No formal operating records are available.

d. Post-Construction Changes. Available information indicates that the two post-construction changes were the deepening of and enlargement of the diversion channel at the entrance of the 9-foot tunnel on the left abutment in 1929 and construction of a new valve chamber at the toe of the dam during the construction of the water treatment plant.

e. Seismic Stability. The dam is located in Seismic Zone 1, and based on visual observations, the static stability of the dam is considered to be adequate. Therefore, according to the recommended criteria for evaluation of seismic stability of dams, the structure is assumed to present no hazard from earthquakes.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Lower Kittanning Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillway and its components, the downstream end of the outlet pipe, and other appurtenant features.

3. Observation of factors affecting the runoff potential of the drainage basin.

4. Evaluation of the downstream area hazard potential.

The specific observations are illustrated in Plate 7 and in the photographs in Appendix C.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features.

1. A depression was observed on the upstream slope of the dam about 300 feet from the left abutment of the dam (Photographs 9 and 10). Measured vertically, the depression was about 18 inches deep at its left extreme and gradually diminished over a distance of 120 feet toward the right abutment.

2. Four wet areas were found on the downstream side of the dam. The first wet area was located on the bench at the toe of the dam near the right abutment. Water was perched on the bench. No measurable seepage was observed. The other three wet areas were located about 100 feet downstream of the toe of the dam. Plate 7 illustrates the location of these wet areas.

c. Appurtenant Structures. The spillway structures, spillway crests, channels, and plunge pool were examined for deterioration or other signs of distress and obstructions that would limit flow. In general, the structures were found to be in fair condition.

The concrete in the diversion channel was found to be deteriorated due to action of acid mine drainage. However, the condition is not considered to be to an extent that would affect the structural performance of the concrete.

The downstream blow-off valve was operated by the city personnel and found to be functional.

d. Reservoir Area. A map review indicates that the watershed area is predominantly covered with woodland, however, a minor portion has been strip mined. A review of the regional geology (Appendix E) indicates that the shorelines are not likely to be susceptible to massive landslides which would affect the storage volume of the reservoir or cause overtopping of the dam by displaced water.

e. Downstream Channel. Overflow from the spillways of Lower Kittanning Dam would directly discharge into the reservoir of Lake Altoona Dam. Downstream from Lake Altoona Dam, the stream goes through residential areas of Altoona and flows into Mill Run, three miles downstream of Lake Altoona Dam south of the city limits of Altoona.

3.2 Evaluation. In view of the depression observed on the upstream slope which is considered to be a threat to the integrity of the dam, the condition of the dam is considered to be poor.

It is considered that further investigation of this condition is required to determine the cause, effect on the overall performance, and extent of remedial measures required.

Field observations indicated that the flow through the combined blow-off and supply line is controlled by downstream valves and no upstream controls exist. It is considered advisable to develop means for at least temporarily blocking the upstream end of this pipe in the event it is required to drain the pipe.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedures. As reported by the city maintenance personnel, no formal procedures exist for operating the dam. The operational feature of the dam which may affect the safety of the dam is the blow-off pipe valve, if it is required to lower the reservoir.

The clearing of debris from the spillway as required and the continued inspection of the facilities by the dam tender are the principal maintenance operations which would affect safety.

4.2 Maintenance of the Dam. The overall maintenance conditions of the dam are considered to be good. Periodic removal of brush from the downstream face of the dam is required.

4.3 Maintenance of Operating Facilities. The blow-off valve located at the downstream valve chamber was operated by the city personnel and observed to be functional. Visual observations indicate that the operating equipment is in good condition.

4.4 Warning System. No formal warning system exists for the dam. The dam is maintained by the city personnel operating from Altoona, about four miles from the site. Telephone communication is available from the offices of the water treatment plant.

4.5 Evaluation. The operational condition of the dam is considered to be good. However, it is considered advisable to develop a means of blocking the upstream end of the blow-off pipe in the event it is required to repair the pipe.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation

a. Design Data. Lower Kittanning Dam has a direct watershed of 0.35 square mile and also receives the overflow from the primary spillway of Upper Kittanning Reservoir, which, in turn, receives controlled inflow from a diversion channel which bypasses both reservoirs. The diversion channel at Lower Dam has a watershed of 9.8 square miles.

Inflow into the Lower Kittanning Dam would be discharged through the primary and emergency spillways into Lake Altoona. The combined capacity of the spillways is estimated to be 2900 cfs. The next outflow control section for the dam is the capacity of the spillway discharge channel (Plate 7), which would receive flow both from the spillways of the dam and from the diversion channel when the flow in the diversion channel exceeds the capacity of the tunnel (1300 cfs). The capacity of the spillway discharge channel is estimated to be 6700 cfs with no freeboard.

The full storage volume of the upstream Upper Kittanning Dam is estimated to be 270 acre-feet, which is greater than the surcharge storage volume of Lower Kittanning Dam (250 acre-feet). Therefore, it is estimated that failure of the Upper Kittanning Dam would result in the overtopping of Lower Kittanning Dam.

It is further estimated that the failure of Lower Kittanning Dam due to overtopping would result in the failure of the downstream Lake Altoona Dam, and combined discharge might cause large loss of life and property damage in Altoona.

b. Experience Data. Lower Kittanning Dam is classified to be an "intermediate" size dam in the "high" hazard category. Under recommended criteria for evaluating spillway capacity, such impoundments are required to pass full PMF.

The adequacy of the flood discharge capacity of the dam was analyzed based on the simplified procedure provided by the U.S. Army Corps of Engineers. Based on this procedure, it was determined that the PMF inflow hydrograph will have a peak flow of 24,000 cfs and a total volume of approximately 14,000 acre-feet. Since the surcharge storage volume of the upstream reservoir (70 acre-feet) is much smaller than the total volume of the PMF, the effect of the upstream reservoir in reducing the peak flow rate is negligible.

Review of the hydraulic features of the dam indicates that two possible control sections exist which may determine the flood discharge capacity

of the reservoir. One is the combined capacity of the spillways to discharge the flow entering Lower Kittanning Dam via Upper Kittanning Dam. The second is the combined capacity of the spillway discharge channel and the tunnel to pass flow from the diversion channel and the overflow from the spillways.

An analysis (Appendix D) conducted assuming that overtopping of the Upper Kittanning Dam would not result in sudden failure indicated that the flood discharge capacity of the dam would be controlled by the capacity of the spillway discharge channel. For this case, it was determined that the dam would pass 33 percent PMF with the tunnel fully functional and 28 percent PMF if the tunnel is blocked. Twenty-eight percent PMF corresponds to the spillway capacity of the upstream reservoir.

c. Visual Observations. Visual observations indicate that the nine-foot tunnel on the diversion channel is likely to be blocked by debris in the event of a major flood.

d. Overtopping Potential. As stated above, the dam will be overtopped during a flood whose magnitude exceeds 28 percent PMF.

e. Spillway Capacity. As previously stated, the capacity of the spillway is less than 50 percent PMF. It is estimated that overtopping of the dam would result in failure of the dam and downstream damage potential would significantly increase compared to that which would exist just before overtopping failure.

Based on the above results, the spillway is classified to be "seriously inadequate" according to the recommended criteria.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. As discussed in Section 3, a depression observed on the upstream slope of the dam is considered to require further investigation as to the affect of this condition on the overall performance of the embankment. The appearance of the depression suggests either an upstream slope failure or a sinkhole developing on the upstream slope. Therefore, further investigation should evaluate both seepage through the embankment and structural integrity of the embankment.

b. Design and Construction Data

(1) Embankment. The dam was designed at a time (1892-1898) when limited understanding of the geotechnical behavior of earth structures existed. Consequently, the available design and construction information includes no quantitative data to aid in the assessment of embankment stability.

(2) Appurtenant Structures. No information is available on the structural design of the outlet works.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. No post-construction changes were reported that would significantly affect the stability of the embankment.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. In view of the depression observed on the upstream slope of the dam which is considered to be a potential threat to the integrity of the embankment, the condition of Lower Kittanning Dam is assessed to be poor.

Immediate further investigation of this condition as it might affect seepage through the embankment and stability of the embankment should be undertaken. In the interim, the lake level should be maintained at a level not higher than 15 feet below the crest of the dam.

The spillway was considered to be "seriously inadequate" because its capacity (28 percent PMF) is less than 50 percent PMF and because it is estimated that overtopping of the embankment would result in failure, significantly increasing the hazard potential which existed just prior to overtopping.

b. Adequacy of Information. The available information in conjunction with visual observations and previous experience of the inspectors are considered to be sufficient to make a reasonable assessment of the dam.

c. Urgency. Further evaluation of the effect of the observed depression on the integrity of the embankment and more detailed evaluation of the spillway should be made immediately and other recommendations below should be implemented as soon as practicable or on a continuing basis.

d. Necessity for Further Investigation. The effect of the upstream slope depression on the integrity of the embankment and spillway is considered to require immediate further investigation.

7.2 Recommendations/Remedial Measures

1. It is recommended that the effect of the depression on stability and seepage through the embankment should be investigated by a professional geotechnical engineer.

   The lake level should be maintained at a level not higher than 15 feet below the crest of the dam until further investigation is undertaken and appropriate repairs completed.

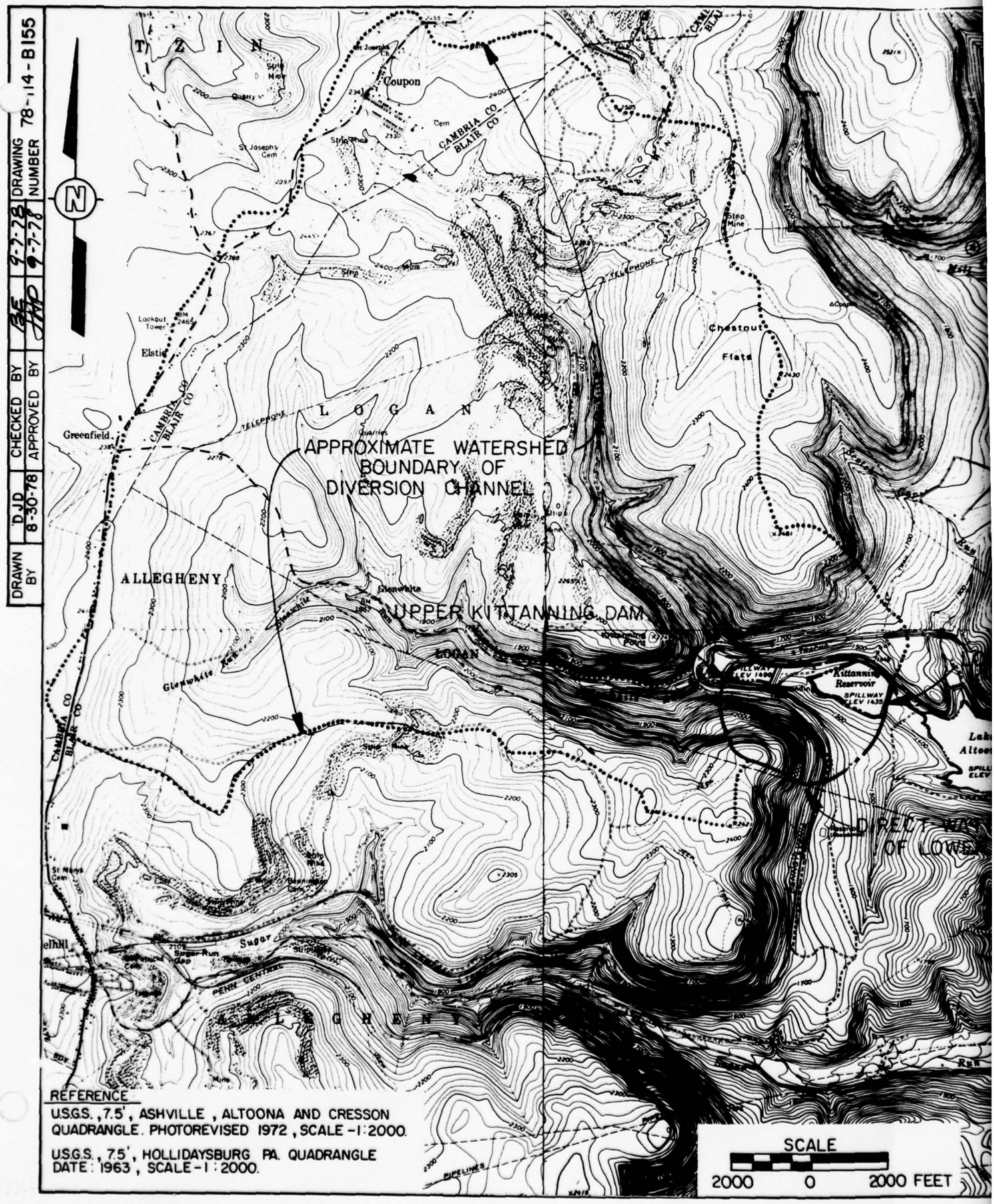
2. In view of the "seriously inadequate" spillway capacity, the owner should initiate additional hydrology and hydraulic studies to more accurately ascertain the spillway capacity and to determine the nature and extent of remedial measures required to increase the spillway capacity.

3. It is recommended that the owner should provide around-the-clock surveillance during unusually heavy runoff and develop a formal warning system to alert the downstream residents in the event of an emergency.

4. Flow through the reservoir outlet pipe is controlled by downstream valves. It is considered advisable for the owner to develop means for at least temporarily blocking the upstream end of this pipe.

5. It is recommended that the owner be advised that the dam and appurtenant structures should be inspected regularly and necessary maintenance should be performed.

PLATES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L O G A N
A L L E G H E N Y
APPROXIMATE WATERSHED BOUNDARY OF DIVERSION CHANNEL
UPPER KITTANNING DAM
Kittanning Reservoir
SPILLWAY ELEV 1435
Coupon
Elstic
Greenfield
Chestnut Flats
Glenwhite
Sugar Run
CAMBRIA CO
BLAIR CO
TELEPHONE
PENN CENTRAL
PIPELINES
REFERENCE
U.S.G.S., 7.5', ASHVILLE, ALTOONA AND CRESSON QUADRANGLE. PHOTOREVISED 1972, SCALE - 1:2000.
U.S.G.S., 7.5', HOLLIDAYSBURG PA. QUADRANGLE DATE: 1963, SCALE - 1:2000.
SCALE
2000 0 2000 FEET

PLATE 1

LOWER DAM

VICINITY, FLOOD PLAIN AND WATERSHED MAP

D'APPOLONIA

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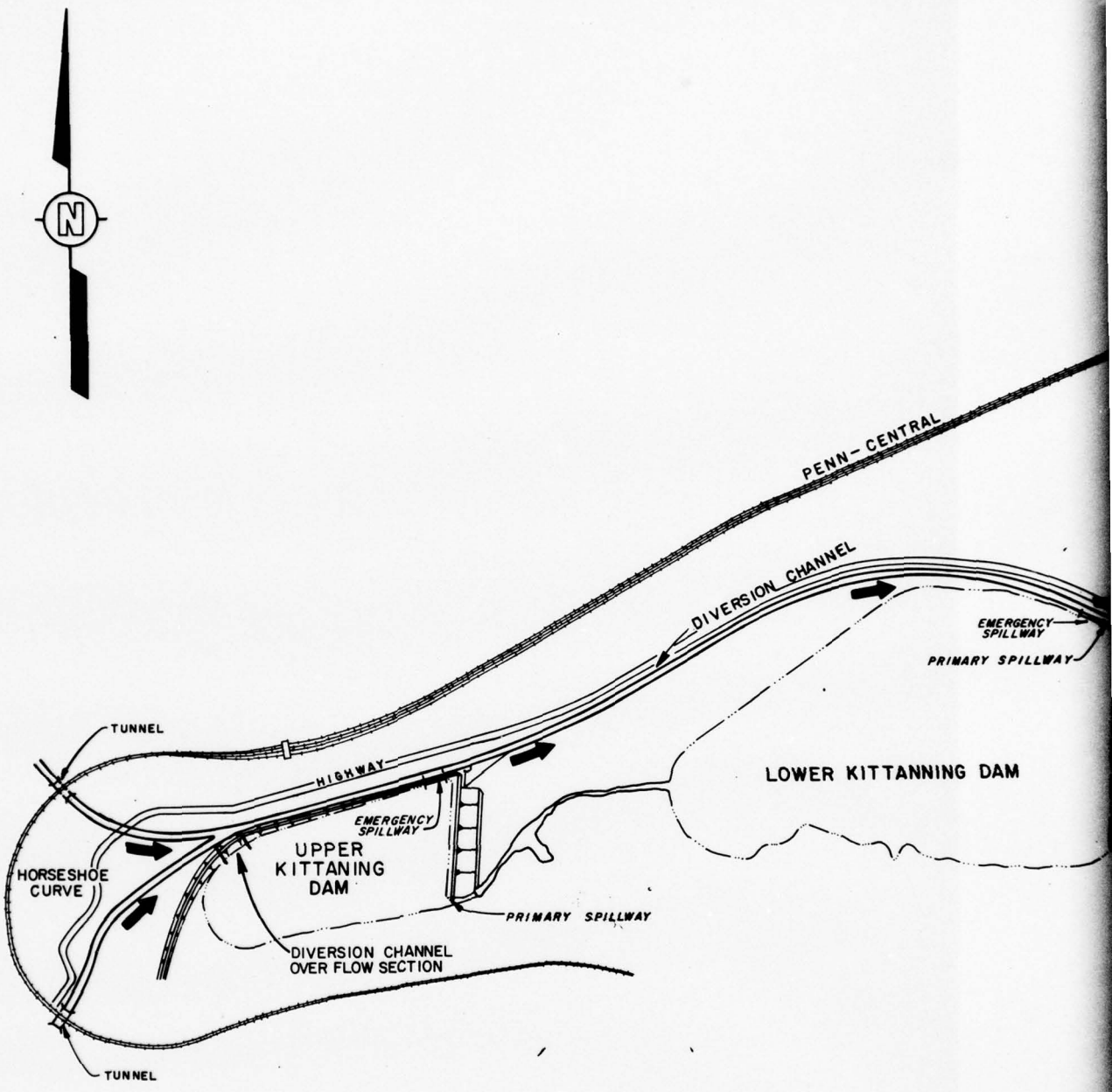

LEGEND

➡ COURSE OF NORMAL FLOW

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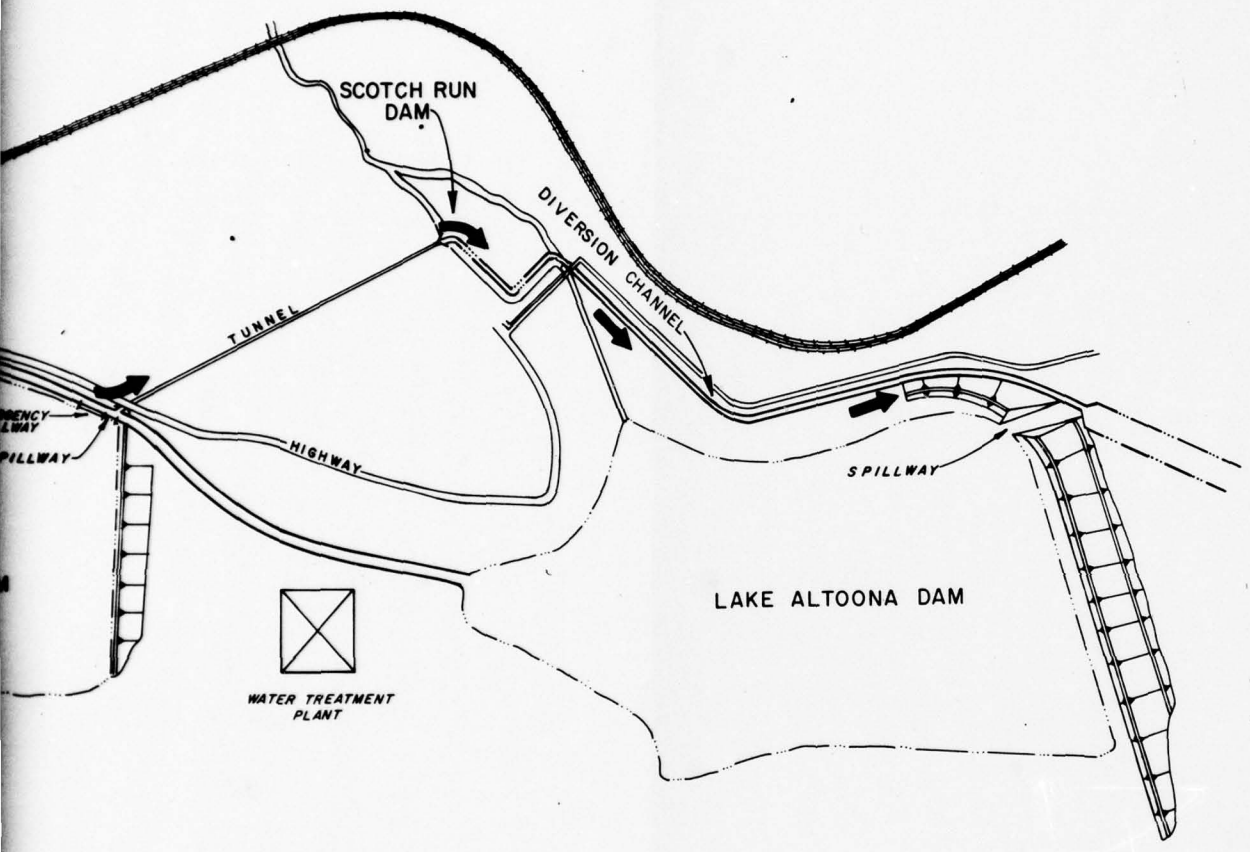

PLATE 2

LOWER DAM

DIVERSION CHANNEL PLAN

D'APPOLONIA

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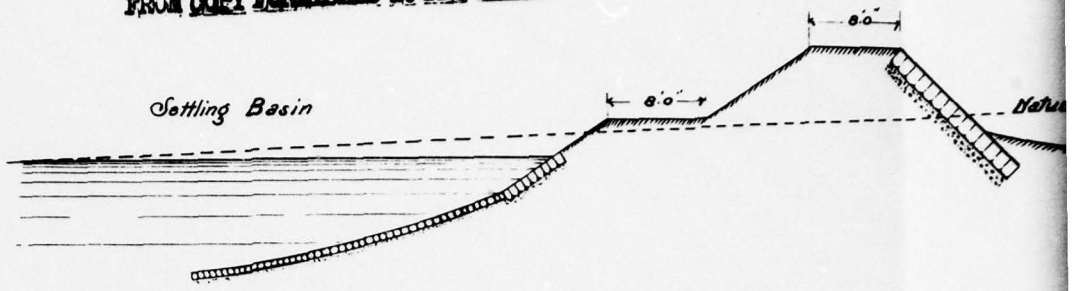
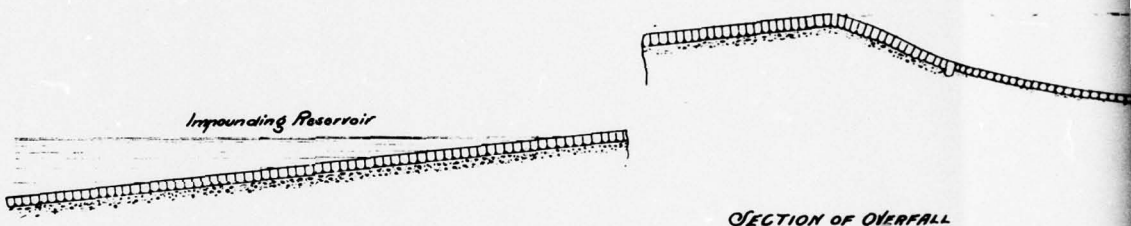
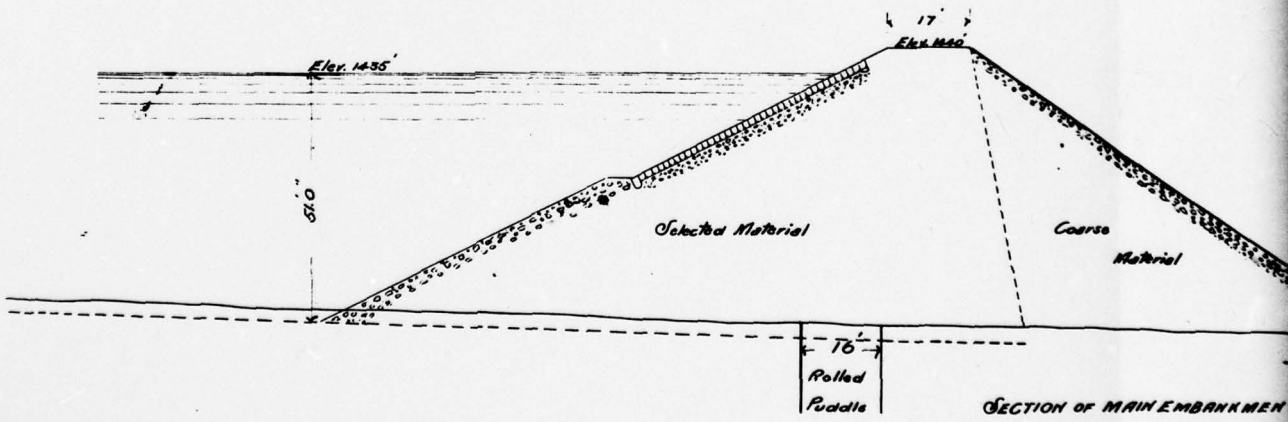
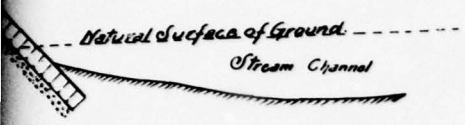




SECTION OF OVERFALL
SCALE 1/8" = 1'



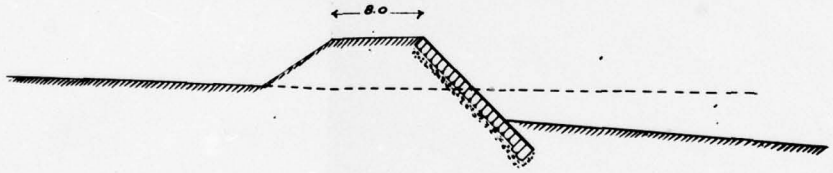
SECTION OF MAIN EMBANKMENT
SCALE 20' - 1"



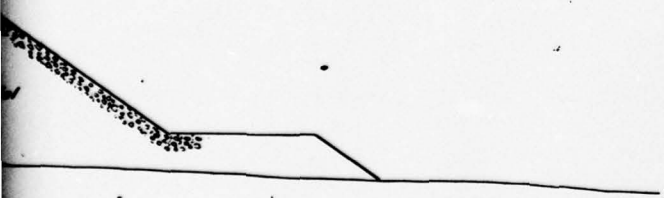
DETAILS
IMPOUNDING RESERVOIR
ALTOONA, PA. WATER WORKS

1902

No. 1863



SECTION OF DIVERTING EMBANKMENT

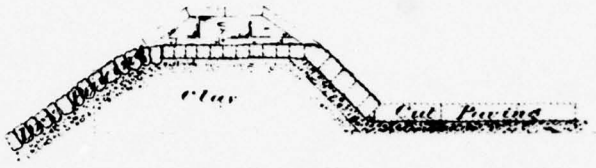


EMBANKMENT.

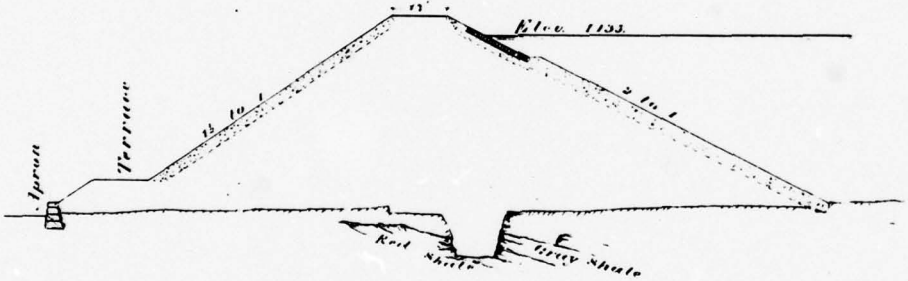
PLATE 3

D'APPOLONIA

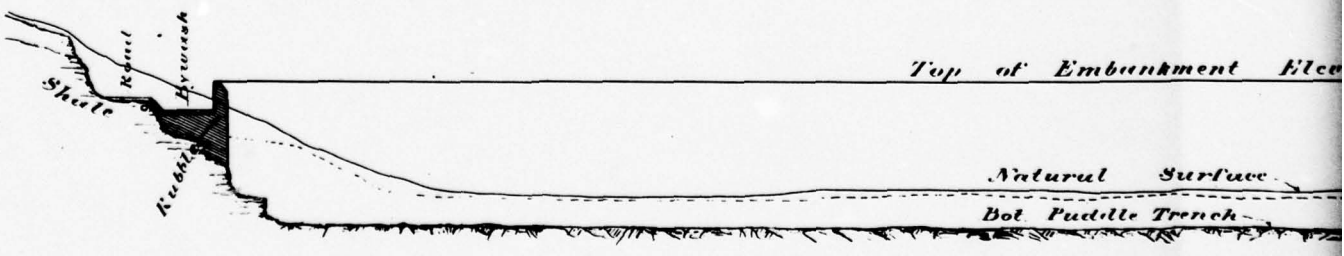
DRAWN BY	D.J.D.	CHECKED BY		9-7-78	DRAWING NUMBER	78-114-B139
	8-30-78	APPROVED BY		9-7-78		



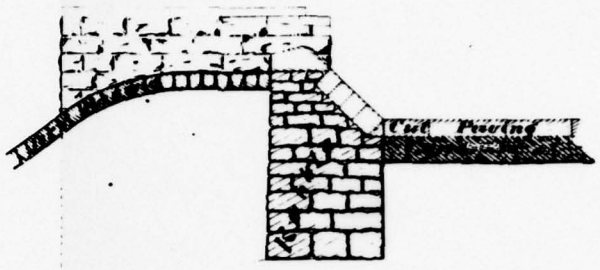
Section of 100 Spillway
Scale



Section Main Embankment
150' from Byewash
Scale

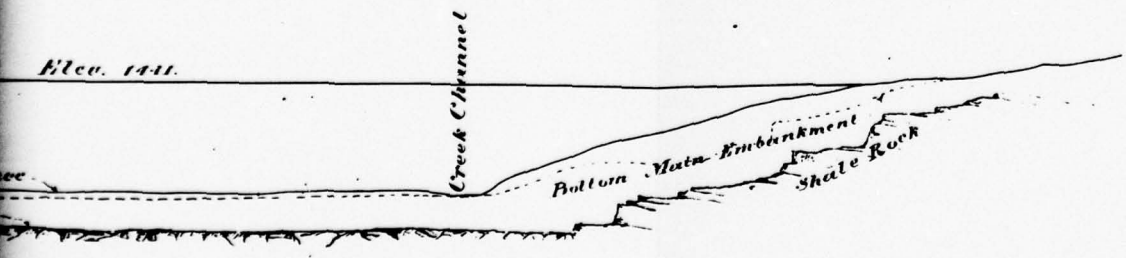


Section on C.L. of Embankm
Scale



Section at 25 Spillway
Scale

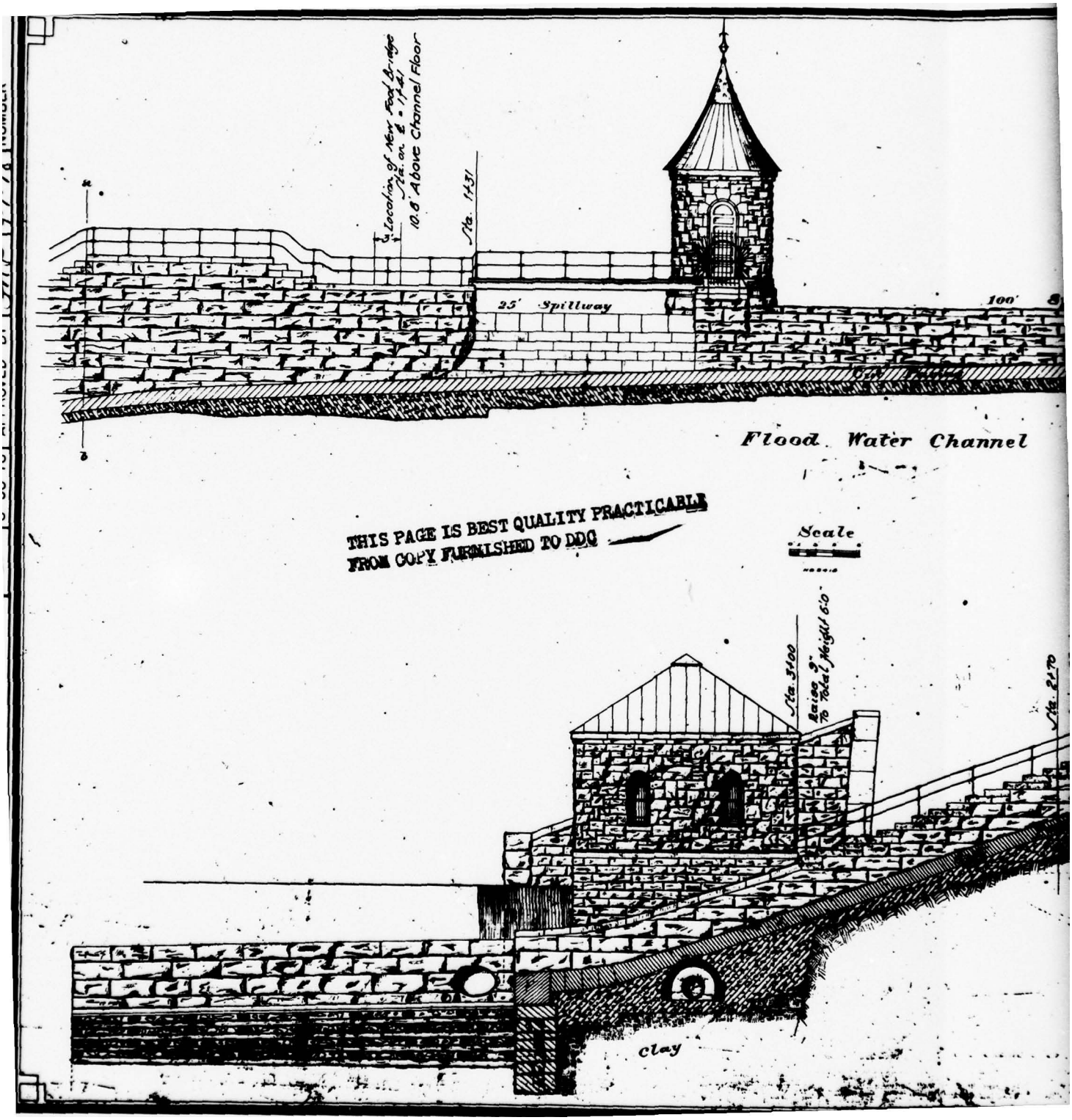
Section of Flood Water Channel and Highway
Scale

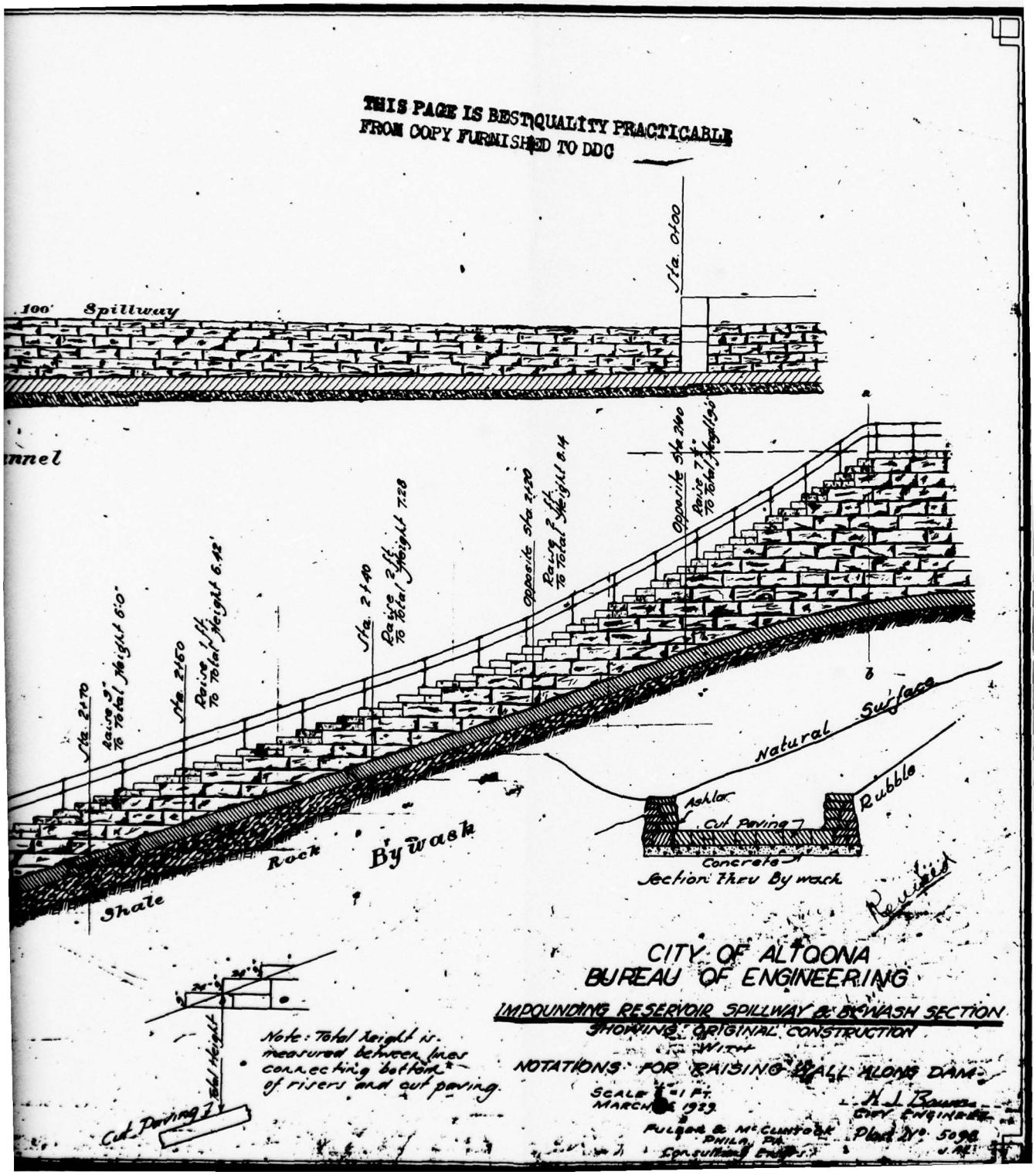


bankment

PLATE 4

D'APPOLONIA





CITY OF ALTOONA
BUREAU OF ENGINEERING

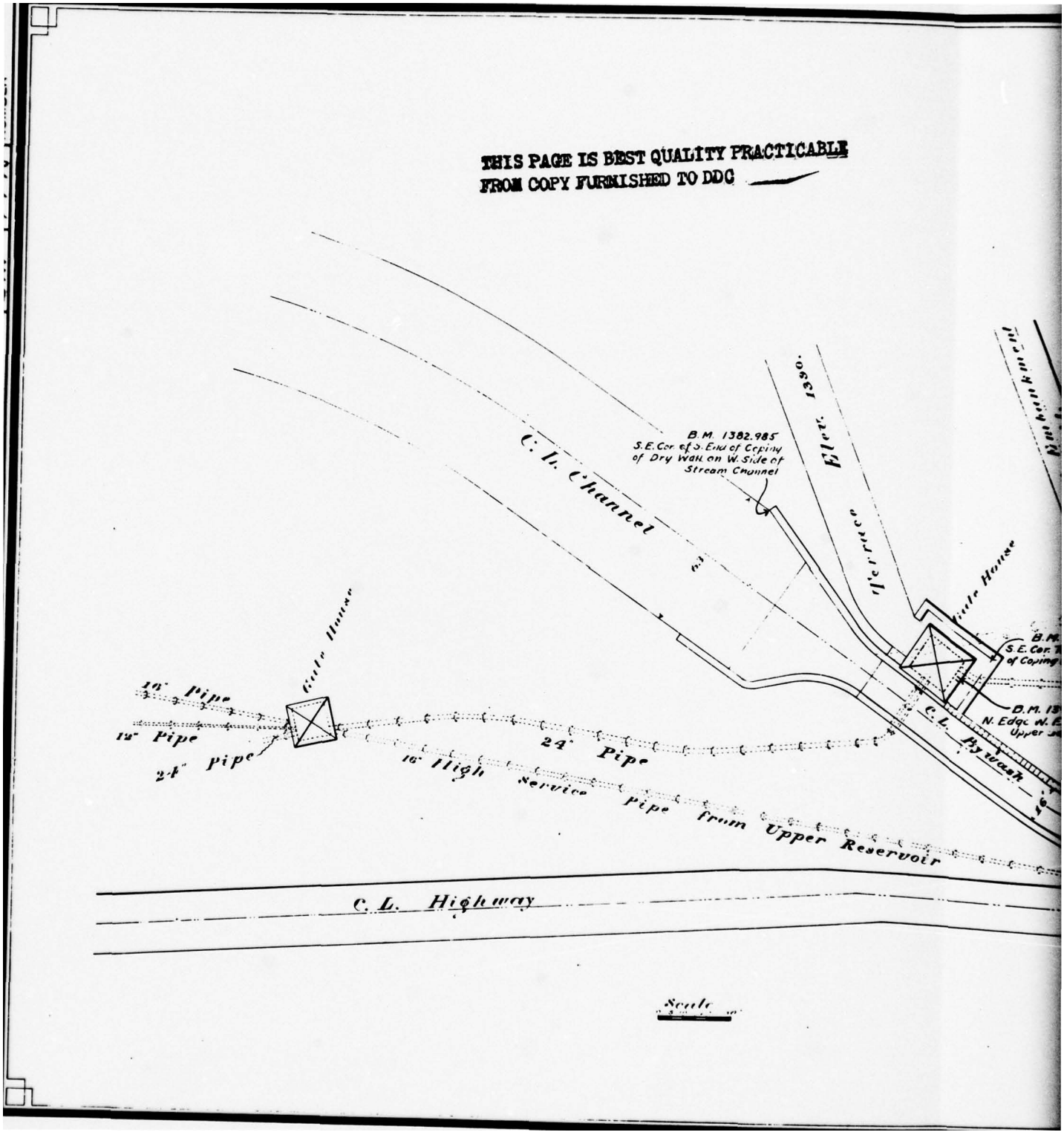
IMPOUNDING RESERVOIR SPILLWAY & BYWASH SECTION
SHOWING ORIGINAL CONSTRUCTION
WITH
NOTATIONS FOR RAISING WALL ALONG DAM

SCALE 1" = 1 FT.
MARCH [illegible] 1923

N. J. Bauer
CITY ENGINEER

Fulton & McClintock
PHILA. PA.
Consulting Engrs.

Plan No. 5098



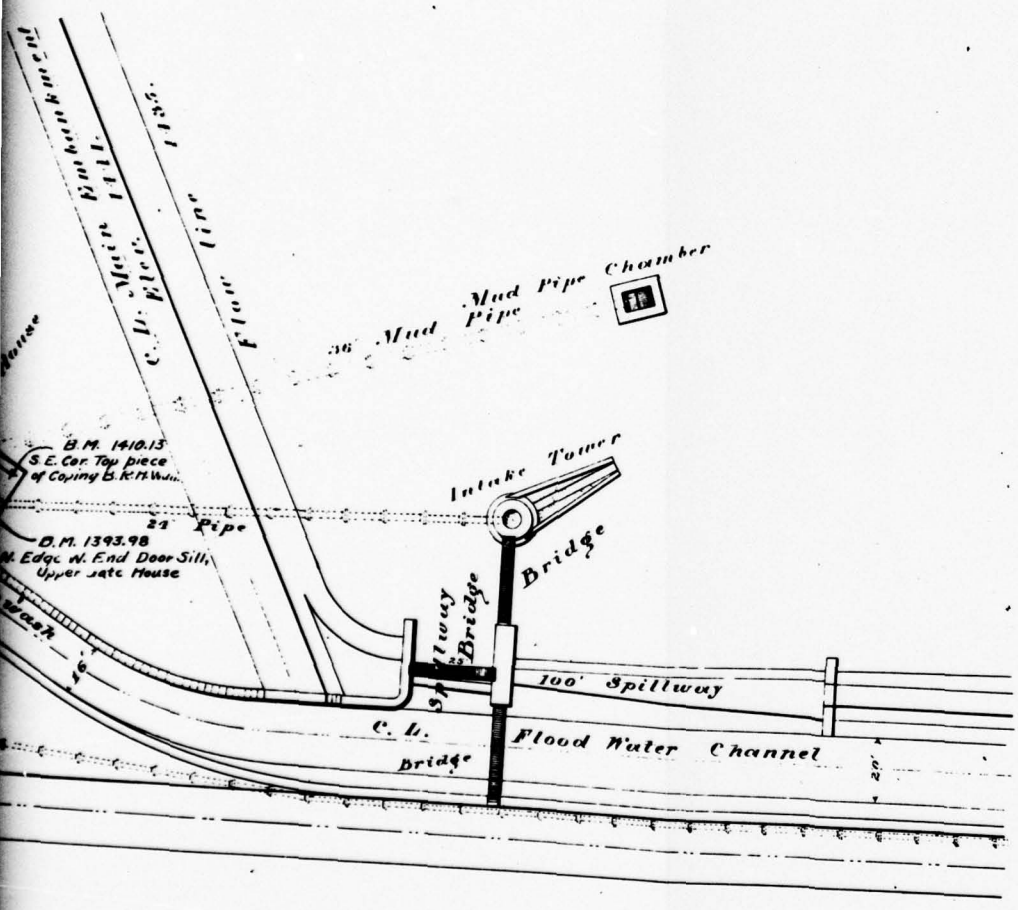


PLATE 6

D'APPOLONIA

2

DRAWN BY	MBM	CHECKED BY		9-7-78	DRAWING NUMBER	114-A24
	8-22-78	APPROVED BY		9-7-78		

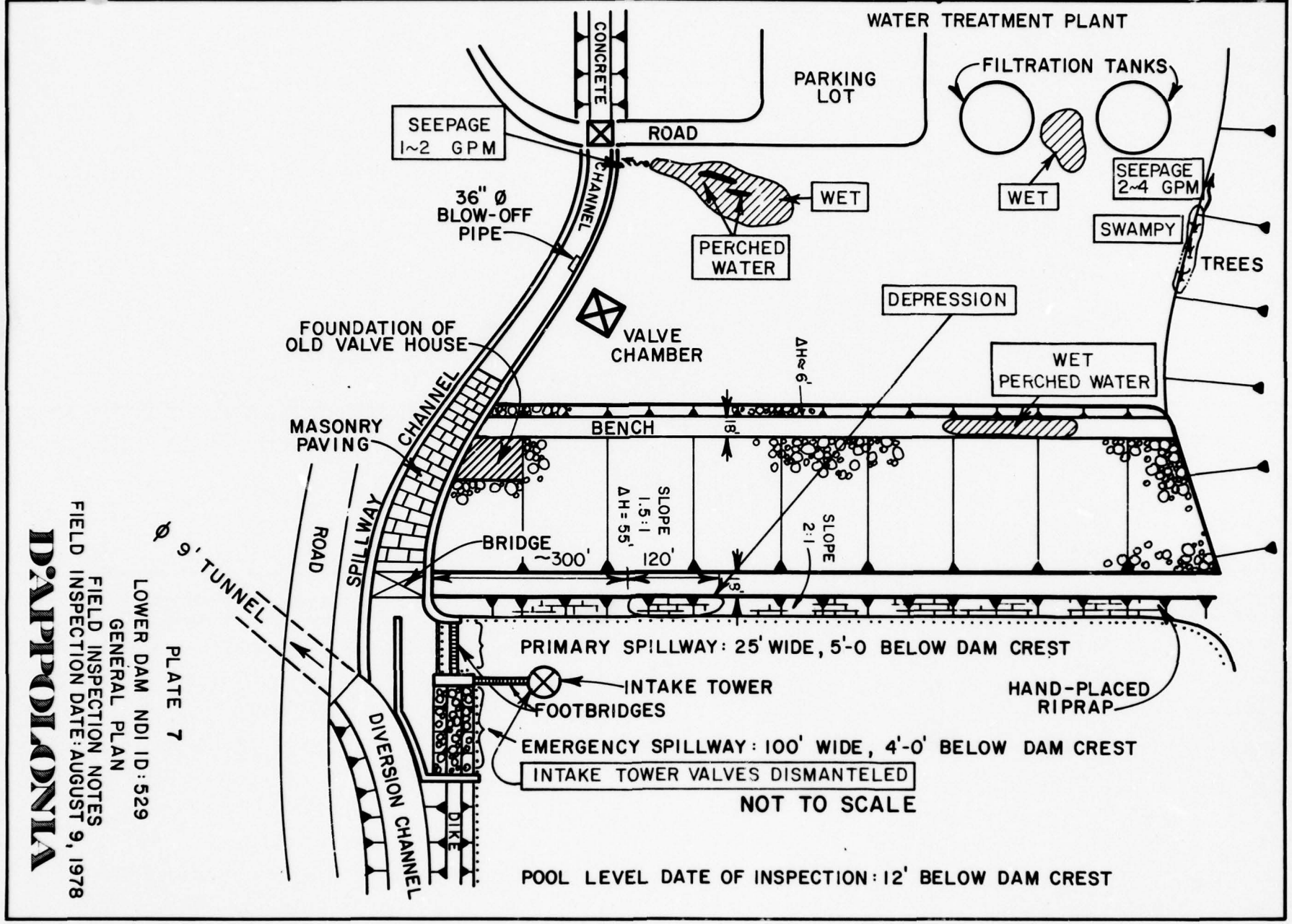


PLATE 7

LOWER DAM NDI ID: 529

GENERAL PLAN

FIELD INSPECTION NOTES

FIELD INSPECTION DATE: AUGUST 9, 1978

D'APPOLONIA

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

CHECKLIST
VISUAL INSPECTION
PHASE I

NAME OF DAM LOWER KITTANNING DAM COUNTY BLAIR STATE PA. ID# NDI : 529
DER : 7-14

TYPE OF DAM EARTH FILL. HAZARD CATEGORY HIGH.

DATE(S) INSPECTION AUGUST 9, 1978 WEATHER SUNNY TEMPERATURE 80's

POOL ELEVATION AT TIME OF INSPECTION 1428 M.S.L. (12-FT BELOW CREST) TAILWATER AT TIME OF INSPECTION 1380± M.S.L.

INSPECTION PERSONNEL:

BILGIN EREL	REVIEW INSPECTION BY AUGUST 16, 1978	ELIO D'APPOLONIA.
NAH-TAK CHAN		L.D. ANDERSEN.
		JAMES POELLOT.

BILGIN EREL. RECORDER

VISUAL INSPECTION
PHASE I
EMBANKMENT

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 530 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	A DEPRESSION WAS OBSERVED ON THE UPSTREAM FACE OF THE DAM ABOUT 300 FT FROM THE LEFT ABUTMENT.	THIS CONDITION IS CONSIDERED TO BE POTENTIAL THREAT TO THE INTEGRITY OF THE DAM.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE FOUND	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	NONE FOUND.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	NO PERCEIVABLE MISALIGNMENT.	
RIPRAP FAILURES	NONE (OTHER THAN THE DEPRESSION REFER ABOVE)	

VISUAL INSPECTION
PHASE I
EMBANKMENT

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	NO VISUAL SIGNS OF DISTRESS NO SEEPAGE.	
ANY NOTICEABLE SEEPAGE	SOME MINOR SEEPS BELOW TOE SEE PLATE 7 FOR LOCATION AND SEEPAGE QUANTITY ESTIMATES.	
STAFF GAGE AND RECORDER	NONE	
DRAINS	NONE.	

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

NAME OF DAM LOWER KITTANNING DAM
ID# NDI:529 DER:7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	(EARTH FILL DAM) N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

NAME OF DAM LOWER KITTANNING DAM.
ID# NDI: 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	EARTHFILL DAM N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS STAFF GAGE OF RECORDER:	N/A.	

VISUAL INSPECTION
PHASE I
OUTLET WORKS

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	OUTLET PIPE (ϕ36") IS CAST IRON ONLY OUTLET END VISIBLE.	
INTAKE STRUCTURE	SUBMERGED NOT VISIBLE.	
OUTLET STRUCTURE	OUTLET PIPE DIRECLY DISCHARGES INTo THE SPILLWAY DISCHARGE CHANNEL.	
OUTLET CHANNEL	CONCRETE SPILLWAY DISCHARGE CHANNEL.	
EMERGENCY GATE	OPERATED BY CITY PERSONNEL. OBSERVED TO BE FUNCTIONAL.	

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	PRIMARY : 25-FT WIDE OGEE CRESTED WEIR. EMERGENCY : 100 FT WIDE BROAD CRESTED WEIR.	
APPROACH CHANNEL	FOR BOTH SPILLWAYS : LAKE.	
DISCHARGE CHANNEL	BOTH SPILLWAY WOULD DISCHARGE INTO DIVERSION CHANNEL	
BRIDGE AND PIERS	FOOT BRIDGE ACROSS PRIMARY SPILLWAY . NONE ACCROSS EMERGENCY SPILLWAY.	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

NAME OF DAM LOWER KITTANNING DAM
ID# NDI : 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	NO GATE SPILLWAY N/A.	
APPROACH CHANNEL	N/A.	
DISCHARGE CHANNEL	N/A.	
BRIDGE PIERS	N/A.	
GATES AND OPERATION EQUIPMENT	N/A.	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

NAME OF DAM LOWER KITTANNING DAM
ID# NDI:529 DER:7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE	
OBSERVATION WELLS	NONE	
WEIRS	NONE	
PIEZOMETERS	NONE	
OTHER	NONE	

VISUAL INSPECTION
PHASE I
RESERVOIR

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	WOODED, STEEP.	
SEDIMENTATION	UNKNOWN	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

NAME OF DAM LOWER KITTANNING DAM.
ID# NDI:529 DER:7-14

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	SPILLWAY DISCHARGE CHANNEL DISCHARGES INTO LAKE ALTOONA ABOUT 300 FT DOWNSTREAM.	
SLOPES	RECTANGULAR CONCRETE CHANNEL.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	IT IS ESTIMATED FAILURE OF THIS DAM WOULD RESULT IN FAILURE OF LAKE ALTOONA DAM AND COMBINED DISCHARGE WOULD FLOW THROUGH ALTOONA.	MAIN IMPACT AREA OF FLOOD: 500 HOMES POPULATION 2000.

APPENDIX B

CHECKLIST
ENGINEERING DATA, DESIGN,
CONSTRUCTION, OPERATION
PHASE I

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM LOWER KITTANNING DAM.
ID# NDI: 529 DER: 7-14

ITEM	REMARKS
AS-BUILT DRAWINGS	VERY LIMITED NUMBER OF DRAWINGS ARE AVAILABLE IN OWNERS FILES.
REGIONAL VICINITY MAP	SEE PLATE 1.
CONSTRUCTION HISTORY	DESIGNED BY MR. C. W. KNIGHT A CONSULTING ENGINEER FROM ROME, NY. CONSTRUCTION WAS COMPLETED IN 1898.
TYPICAL SECTIONS OF DAM	SEE PLATE 3
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	SEE PLATE 6.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	RECORDED BY DAM TENDER AT LAKE ALTOONA DAM.
DESIGN REPORTS	NOT AVAILABLE.
GEOLOGY REPORTS	NOT AVAILABLE.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	NOT AVAILABLE
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	NOT AVAILABLE.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM LOWER KITTANNING DAM
ID# NDI:529 DER:7-14

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	NONE REPORTED.
BORROW SOURCES	UNKNOWN.
MONITORING SYSTEMS	NONE.
MODIFICATIONS	NO SIGNIFICANT MODIFICATIONS REPORTED.
HIGH POOL RECORDS	NOT AVAILABLE.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM LOWER KITTANNING DAM
ID# NDI: 529 DER: 7-14

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	ALTOONA WATER WORKS: REPORT ON SPILLWAYS AND FLOOD CHANNEL MAY 27, 1921 BY ALLEN HAZEN A LETTER REPORT ON SPILLWAYS AND FLOOD CHANNEL OCT 4, 1921 BY ARTHUR E. MORGAN
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	NONE REPORTED.
MAINTENANCE OPERATION RECORDS	NOT AVAILABLE.
SPILLWAY PLAN SECTIONS DETAILS	SEE PLATES 5 & 6
OPERATING EQUIPMENT PLANS AND DETAILS	NOT AVAILABLE.

NAME OF DAM LOWER KITTANING DAM.

ID# NDI: 529 DER: 7-14

CHECKLIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: WOODED, SOME STRIP MINING 10.1 SQ. MILES.

ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 1120 AC-FT @ EL. 1435

ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: SAME AS ABOVE

ELEVATION; MAXIMUM DESIGN POOL: EL 1436

ELEVATION; TOP DAM: EL 1440

CREST:	PRIMARY	EMERGENCY
a. Elevation	1435	1436
b. Type	OGEE	BROAD CRESTED.
c. Width	N/A	10'-0
d. Length	25'-0	100'-0
e. Location Spillover	N/A	N/A.
f. Number and Type of Gates	NONE	NONE

OUTLET WORKS:

a. Type ϕ 36-INCH CAST IRON PIPE

b. Location NEAR LEFT ABUTMENT.

c. Entrance Inverts UNKNOWN

d. Exit Inverts UNKNOWN

e. Emergency Draindown Facilities ϕ 36-INCH PIPE.

HYDROMETEOROLOGICAL GAGES:

a. Type RAIN GAGE

b. Location AT LAKE ALTOONA.

c. Records AVAILABLE IN CITY RECORDS.

MAXIMUM NONDAMAGING DISCHARGE: SPILLWAY CAPACITY Q ≈ 3000 CFS.

APPENDIX C

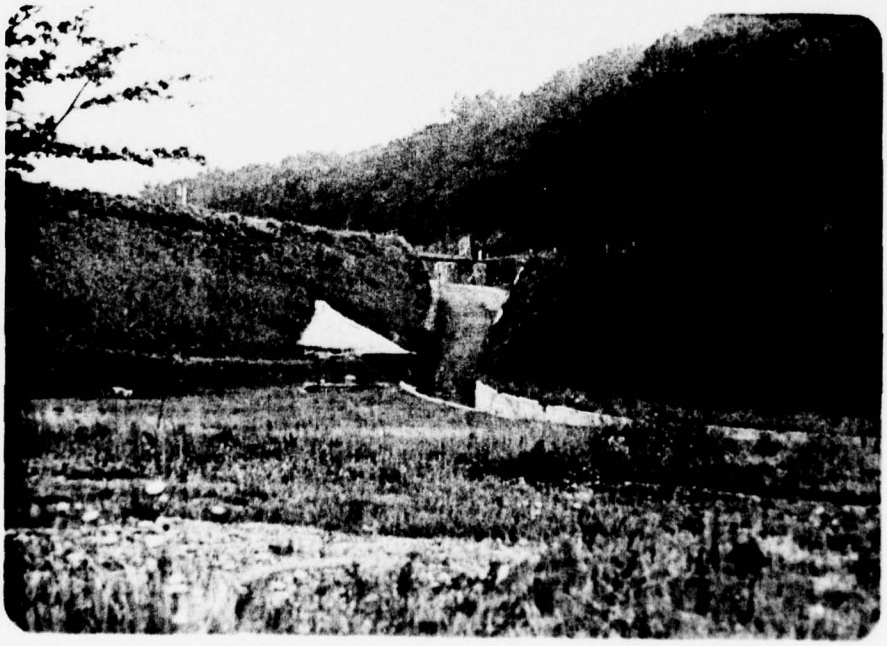
PHOTOGRAPHS

LIST OF PHOTOGRAPHS
LOWER KITTANNING DAM
NDI I.D. NO. 529
AUGUST 9, 1978

PHOTOGRAPH NO.	DESCRIPTION
1	Crest (looking north).
2	Spillway chute.
3	Spillway crest. Reservoir spillway discharge channel (right), diversion overflow (middle), diversion tunnel entrance (left).
4	Diversion channel (note acid mine drainage).
5	Diversion tunnel.
6	Spillway discharge channel (blow-off pipe valve chamber right of channel).
7	Blow-off pipe valve.
8	Downstream: water treatment plant in foreground, Lake Altoona Dam in background.
9	Depression on upstream face.
10	Depression on upstream face (closeup).

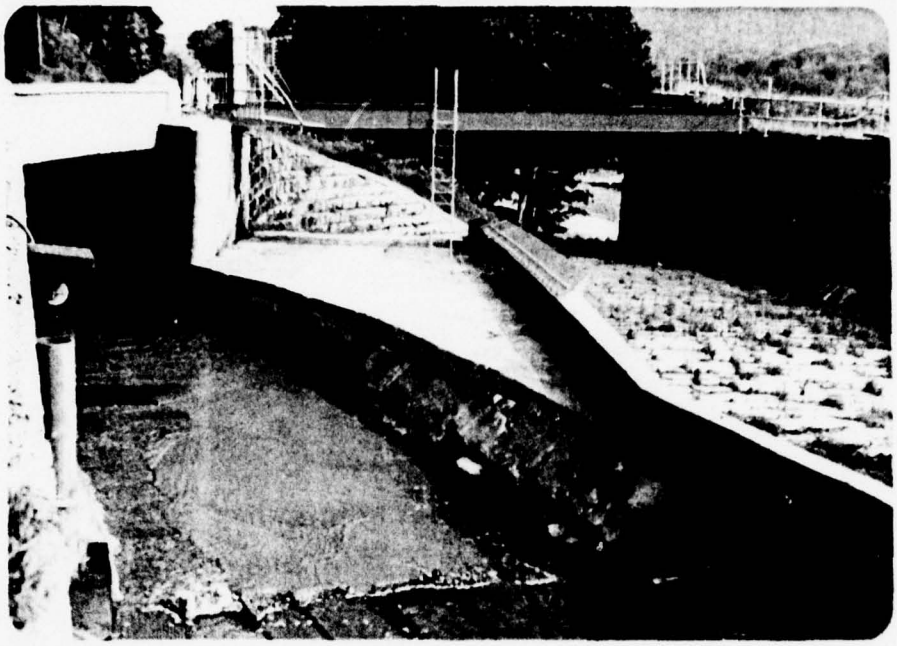
Photograph No. 1

Crest (looking north).



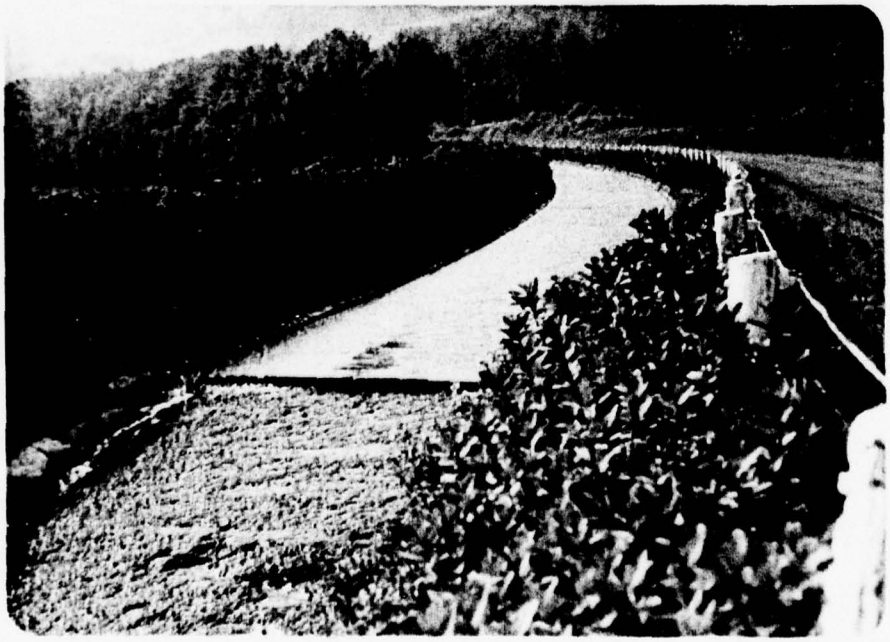
Photograph No. 2

Spillway chute. (Note old valve house foundation right of spillway.)



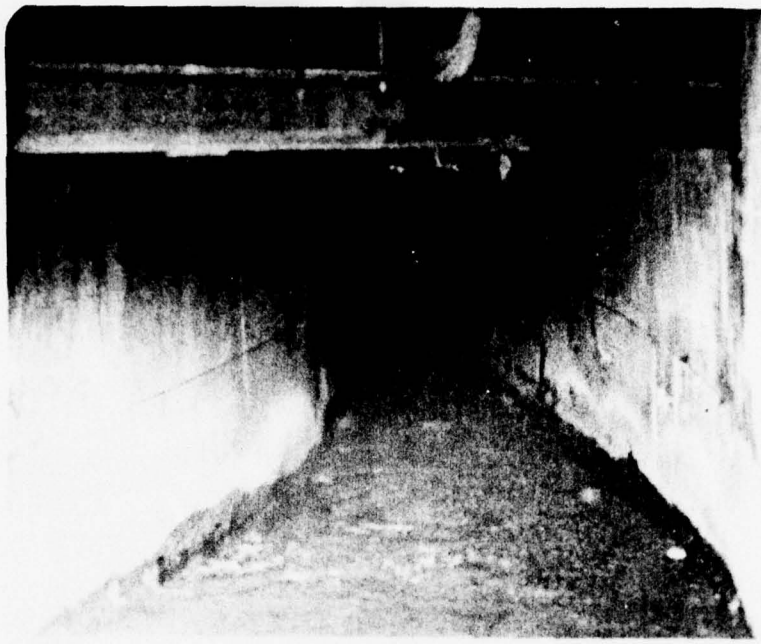
Photograph No. 3

Spillway crest. Reservoir spillway discharge channel (right), diversion overflow (middle), diversion tunnel entrance (left).



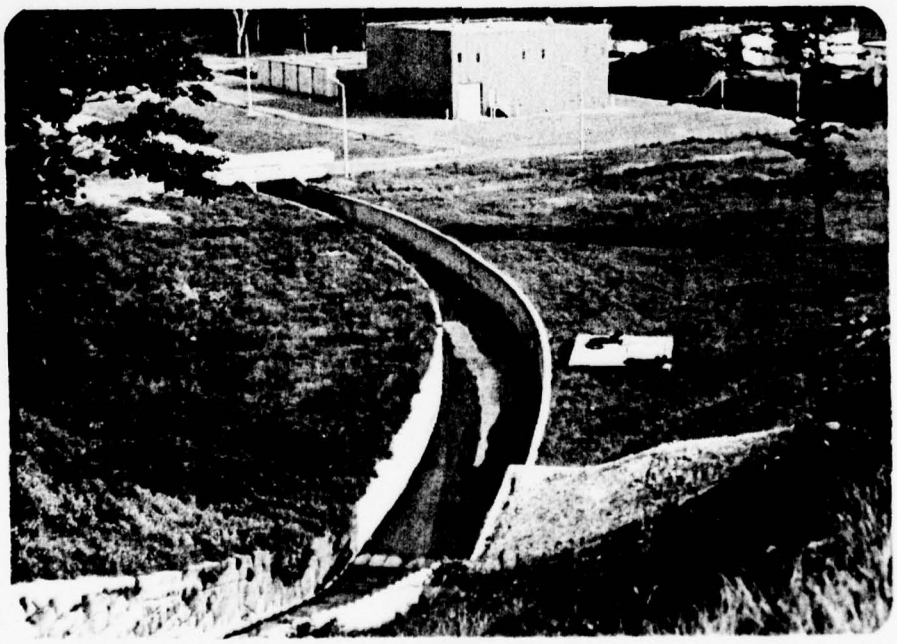
Photograph No. 4

Diversion channel (note acid mine drainage).



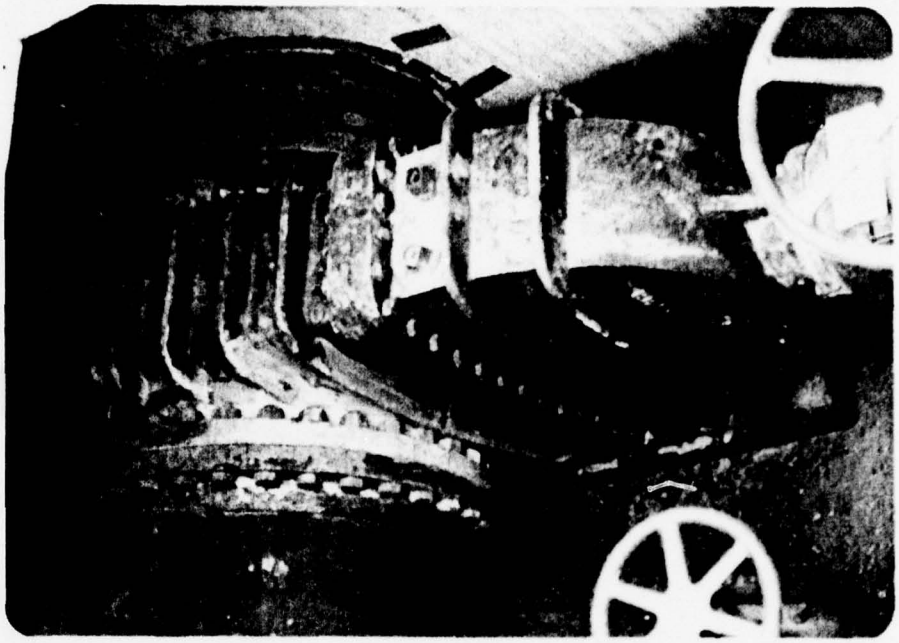
Photograph No. 5

Diversion tunnel.



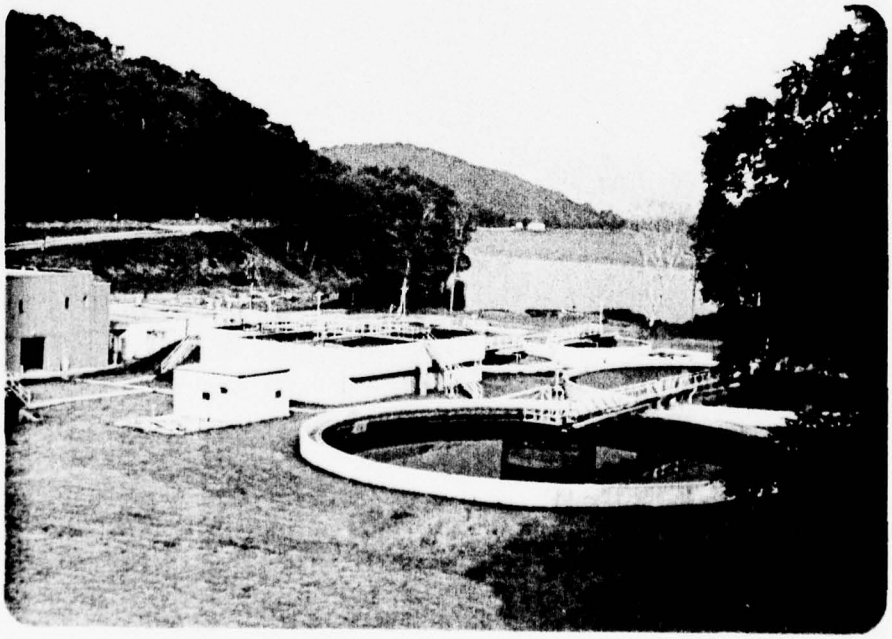
Photograph No. 6

Spillway discharge channel (blow-off pipe valve chamber right of channel).



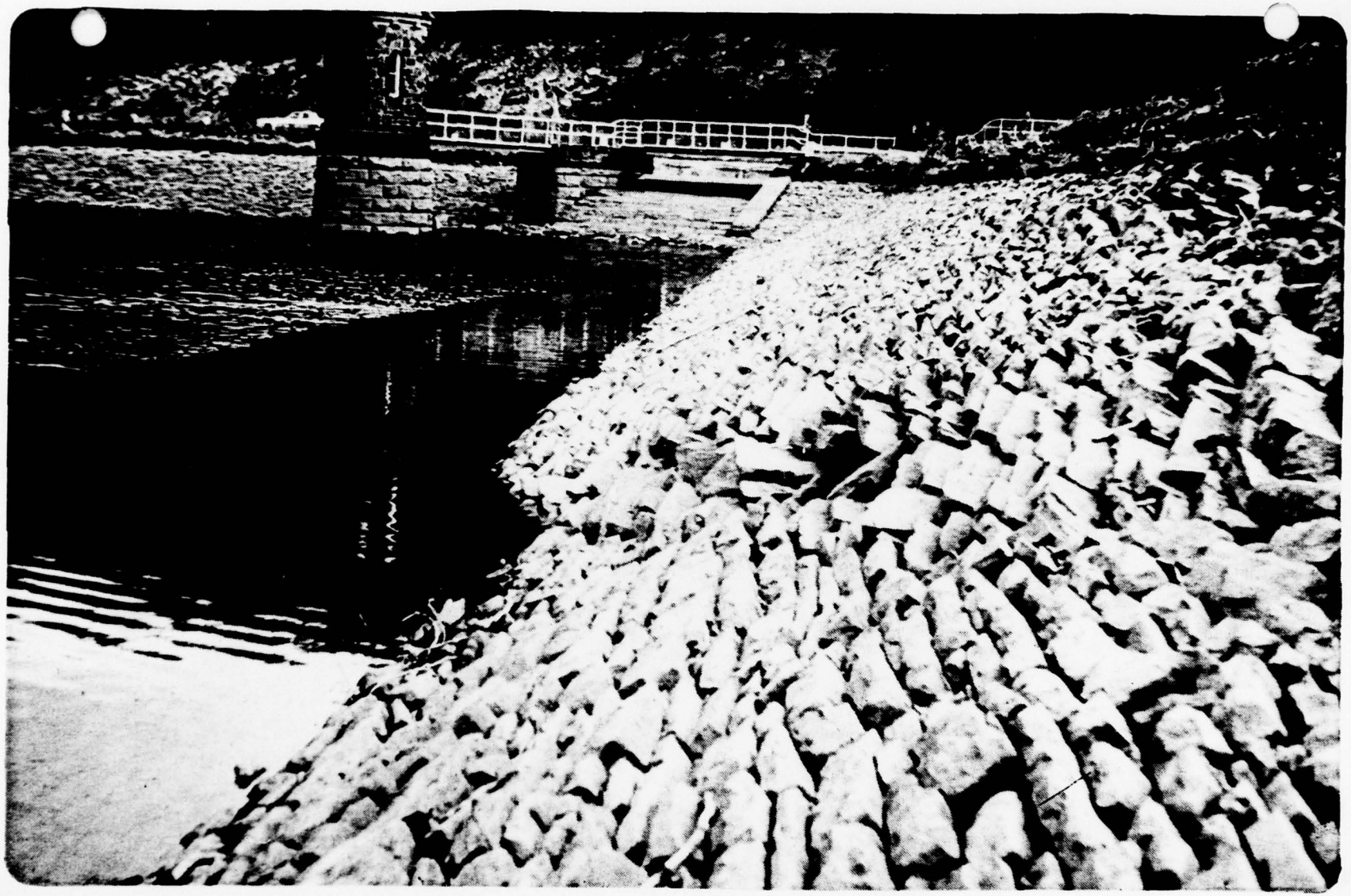
Photograph No. 7

Blow-off pipe valve.



Photograph No. 8

Downstream: water treatment plant in foreground, Lake Altoona Dam in background.



Photograph No. 9

Depression on upstream face.

Photograph No. 10

Depression on upstream face (closeup).

APPENDIX D

CALCULATIONS

IDAHO DIVISION
CONSULTING ENGINEERS, INC

By WTC Date 8-21-78 Subject LOWER KITTANNING WATERSHED AREA Sheet No. 1 of 1
Chkd. By WTC Date 9/2/78 Proj. No 78-114-23

REF. USGS. ALTOONA, HOLLIDAYSBURG, CRESSON AND ASHVILLE QUADRANGLE MAPS, 7.5 MIN. SERIES)

A) WATERSHED AREA FOR LAKE
= 1.85 IN^2 + 0.6 IN^2 = 2.45 IN^2
= 0.35 SQ MILE ← UPPER LAKE

WATERSHED AREA FOR DIVERSION CHANNEL
= (200 − 132) IN^2
= 68 IN^2
= 9.76 SQ. MILE

FOR FLOODS EXCEEDING DIVERSION CHANNEL CAPACITY, WATERSHED FOR THE DAM WOULD BE 10.11 SQ MILE

Say 10.1 SQ MILE

B) LAKE AREA (EL 1435)

LAKE AREA (1435) = 0.95 IN^2
= 41.32 acre

Say 41 acre

AREA @ 1440 (APPROXIMATE DAM CREST ELEV.)
= 0.65 IN^2
= 59.7 acre

Say 60 acre

C) FLOOD SURCHARGE STORAGE

$\Delta V = \frac{5}{3}(41+60+\sqrt{41 \times 60}) = 251.0$ ACRE-ft

Say 250 ac-ft

DAPPOLONIA
CONSULTING ENGINEERS, INC

By WTC Date 8-24-78 Subject LOWER (KITTANNING) DAM Sheet No. 1 of 9
Chkd. By [illegible] Date 9/2/78 HYDROLOGY & HYDRAULIC Proj. No. 78-114-23

DAM · LOWER (KITTANNING) DAM, NEAR ALTOONA PA

WATERSHED AREA $A_1 = 0.35$ SQ MILES FOR LAKES
$A_2 = 9.8$ " " FOR DIVERSION

$\Sigma A = 10.1$ SQ. MILES

ACCORDING TO THE CHARTS provided By COE Baltimore Dist FOR SUSQUEHANNA (Region 1) Basin

PMF MAX Peak inflow = 2380 cfs/SQ.MILE
= 24038 cfs

Say 24000 cfs

TOTAL RUNOFF OF 26" WILL PROVIDE WATER VOLUME of

$V_1 = \frac{26}{12} \times 10.1 \times 640$

= 14005 ac.ft

Say 14000 ac.ft

SURCHARGE STORAGE Volume available BETWEEN NORMAL POOL EL 1435 AND DAM CREST EL 1440
$V_S = 250$ ac.ft

Spillway Discharge Capacity

Primary
Type OGEE-LIKE CONCRETE OVERFLOW WEIR
$L = 25$ FT $\Delta H = 4.83$ FT (field measurement)
$Q_S = C L H^{1.5} = (3.6)(25)(4.83)^{1.5}$
= 955 cfs Say 950 cfs

EMERGENCY SPILLWAY

Type - BOARD CREST OVERFLOW WEIR
$L = 100'$ $\Delta H = 3.83$ FT

$$Q_s = (2.6)(100)(3.83)^{1.5}$$

$$= 1948 \text{ cfs}$$ say 1950^{cfs}

TOTAL DISCHARGE CAPACITY

$$= 950 + 1950$$

$$\boxed{Q_s = 2900^{cfs}}$$

MOST OF THIS FLOW IS FED FROM UPPER KITTANNING PRIMARY SPILLWAY WHICH HAS A MAX. CAPACITY OF 1040^{cfs} IN 28% PMF (5390^{cfs} CARRY BY DIVERSON, $Q_T = 6430^{cfs}$).

UPPER KITTANNING HAS A TOTAL STORAGE VOLUME OF 65×10^6 gal OR 199 ac-ft plus SURCHARGE OF 70 ac-ft, EQUAL TO 270^{ac-ft}. THEREFORE THE LOWER KITTANNING WHICH HAS $V_s = 250^{ac-ft}$ and $Q_s = 2900^{cfs}$ COULD NOT STORE THE WATER IF UPPER DAM FAILS. THEREFORE NEGLECT THE SURCHARGE AFFECT IN "PERCENT OF PMF" CALCULATION IN P.8

DETERMINE THE MAX. INFLOW INTO LOWER DAM WHEN THE OVER FLOW FROM THE DIKE OVERFLOW SECTION ABOVE THE UPPER DAM EQUALS THE TOTAL SPILLWAY CAPACITY OF THE LOWER DAM

1) FROM UPPER DAM CALCULATION, FOR HEAD REQ'D FOR Q_3 (DIVERSION CHANNEL OVERFLOW SECTION) WOULD BE

$Q = 2900^{cfs} = (2.6)(98)(H)^{1.5}$ (LOWER DAM SPILLWAY CAPACITY)

$H = 5.06' > (4.5$ available)

OVERTOPPING OF DIKE COULD OCCUR ($Q_{max} = 2430^{cfs}$)

FOR PRACTICAL PURPOSE USE $H = 4.5 + 4.5' = 9'$ TO CALCULATE DIVERSION FLOW (SEE UPPER KITTANNING CALC.)

$Q_1 = 3370^{cfs}$
$Q_2 = 2682$
TOTAL $Q = 6052^{cfs}$

} TOTAL FLOW IN DIVERSION CHANNEL when DEPTH OF FLOW = 9'

Say 6050^{cfs} DIVERSION

2) CHECK WATER DEPTH IN CHANNEL: (Depth avail. = 8' or more) BELOW OVER FLOW SECTION

CHANNEL slope 2% or steeper BOTTOM WIDTH = 20', $n = 0.015$

FOR $d = 6'$ $Q = 5707^{cfs}$
$d = 7$ $Q = 7481^{cfs}$ OK

TOTAL $Q = 2430 + 6050$
$= 8480^{cfs}$

(TOTAL FLOW INTO LOWER DAM WHEN FLOW THROUGH THE UPPER DAM EQUALS SPILLWAY CAPACITY OF LOWER DAM)

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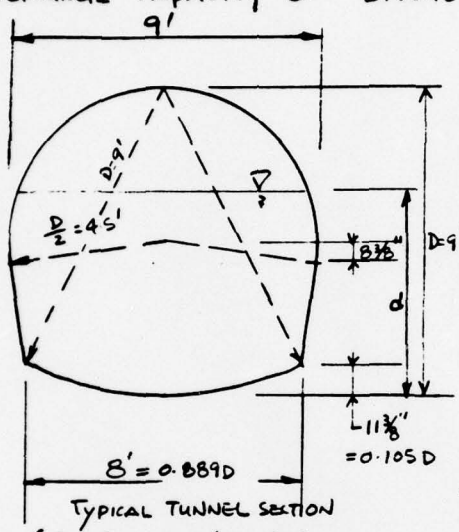
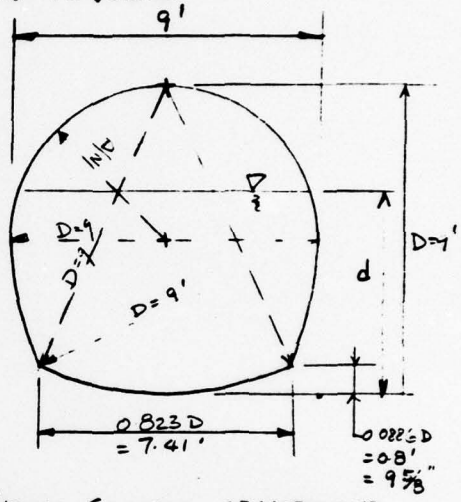
By WTC Date 8-24-78 Subject LOWER (KITTANNING) DAM Sheet No. 4 of 9
Chkd. By MC Date 9/8/78 HYDROLOGY & HYDRAULIC Proj. No. 78-114.25

DISCHARGE CAPACITY OF DIVERSION TUNNEL



Typical TUNNEL SECTION
(Ref Dwg March 26, 1929
CITY OF ALTOONA, BUREAU OF
ENGINEERING, Plan No. 5099)



Typical GEOMETRY OF HORSESHOE
(Ref P.560 DESIGN OF SMALL DAM
2nd EDITION 1973)

BY COMPARING THE ABOVE SECTIONS IT IS POSSIBLE TO USE THE "HORSESHOE" FROM DSM FOR THE CALCULATIONS OF TUNNEL CAPACITY. THEREFORE THE CRITICAL & NORMAL DEPTH ARE DETERMINED AS FLOW

DAM EL 1440
U/S INV EL 1421.92
MAX d = 18.08FT

D/S INVEL 1409 dH = 12.9

L = 1210 FT

SLOPE = $\frac{12.9}{1210} \doteq 1\%$

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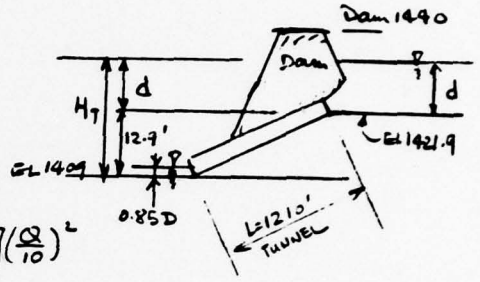
By WTC Date 8-24-78 Subject LOWER (KITTANNING) DAM Sheet No. 5 of 7
Chkd. By CMS Date 9/8/78 HYDROLOGY & HYDRAULIC Proj. No. 78-114-23

UNIFORM FLOW, TABLE B-5							CRITICAL FLOW TABLE B-4			
d	$\frac{d}{D}$	$\frac{A}{D^2}$	A Ft^2	$\frac{Qn}{D^{8/3}S^{1/2}}$	Q cfs	V fps	$\frac{Q_c}{D^2.5}$	$\frac{d_c}{D}$	d_c	
0.5	0.06	0.0275	2.2	.00473	11	5.0	0.0455	0.0723	0.65	SUPERCRITICAL
1	0.11	0.0670	5.4	.01768	41	7.6	0.1700	0.1394	1.25	
1.5	0.17	0.1188	9.6	0.0420	98	10.2	0.4032	0.2234	2.01	n = 0.015
2	0.22	0.1640	13.3	0.0674	157	11.9	0.6481	0.2924	2.63	S = 1%
2.5	0.28	0.2202	17.8	0.1027	240	13.5	0.9875	0.3728	3.36	D = 9 FT
3	0.33	0.2683	21.7	0.1355	319	14.7	1.3124	0.44.	3.96	
3.5	0.39	0.3271	26.5	0.1781	416	15.7	1.7124	0.5134	4.62	
4	0.44	0.3767	30.5	0.2156	504	16.5	2.073	0.5730	5.16	
4.5	0.50	0.4366	35.4	0.2625	613	17.3	2.524	0.6403	5.76	
5	0.56	0.4965	40.2	0.311	727	18.1	2.990	0.7025	6.32	
5.5	0.61	0.5457	44.2	0.351	820	18.6	3.3749	0.7428	6.74	
6	0.67	0.6033	48.9	0.398	930	19.0	3.8268	0.7973	7.18	
6.5	0.72	0.6493	52.6	0.434	1014	19.3	4.1729	0.8301	7.47	
7	0.78	0.7012	56.8	0.473	1105	19.5	4.5479	0.8612	7.75	SUPERCRITICAL & CHANNEL FLOW
7.5	0.83	0.7408	600	0.500	1168	19.5	4.8072	0.8800	7.92	
8	0.89	0.7823	63.4	0.523	1222	19.3	5.0226	0.8941	8.05	
8.5	0.94	0.8101	65.6	0.530	1238	18.9	5.0759	0.9082	8.17	NOTE: ERRATIC FLOW OCCUR
9	1.00	0.8293	67.2	0.494	1154	17.2	4.7495	0.8759	7.88	

OUTLET CONTROL.

INVEL OF TUNNEL 1421.92
LENGTH = 1210 FT
d_{max} = 1440 − 1421.9 = 18.1 FT



Ref. DSM P. 567

$$H_T = \left[\frac{(25204)(1+K_e)}{D^4} + \frac{466.18\,n^2 L}{D^{16/3}}\right]\left(\frac{Q}{10}\right)^2$$

FOR D = 9', K_e = 0.5 (ENTRANCE LOSS), n = 0.015 (aged concrete) and L = 1210'

$$H_T = \left[\frac{(25204)(1.5)}{(9)^4} + \frac{(466.18)(0.015)^2(1210)}{(9)^{16/3}}\right]\left(\frac{Q}{10}\right)^2$$

$$Q = 249.26\sqrt{H_T}$$

$$= 249.26\sqrt{12.9 + d - 0.85(9)}$$

$$= 249.26\sqrt{5.25 + d} \quad \text{-------- EQ-1}$$

FOR TUNNEL CROSS-SECTION AREA = 67.2 FT^2 (Sht 5)

EQ. DIAM = $\sqrt{\frac{67.2 \times 4}{\pi}}$ = 9.25 FT

$$Q = 266.38\sqrt{5.25+d} \quad \text{---------EQ-2}$$

d FT		6"	8"	10	12	14	16	18
H_T FT		11.25	13.25	15.25	17.25	19.25	21.25	23.25
Q, cfs	EQ 1	836	907	973	1035	1094	1149	1202
	EQ 2	893	970	1040	1106	1169	1228	1284

* TRANSITION ZONE

Say $Q_{max} \approx 1200$ cfs

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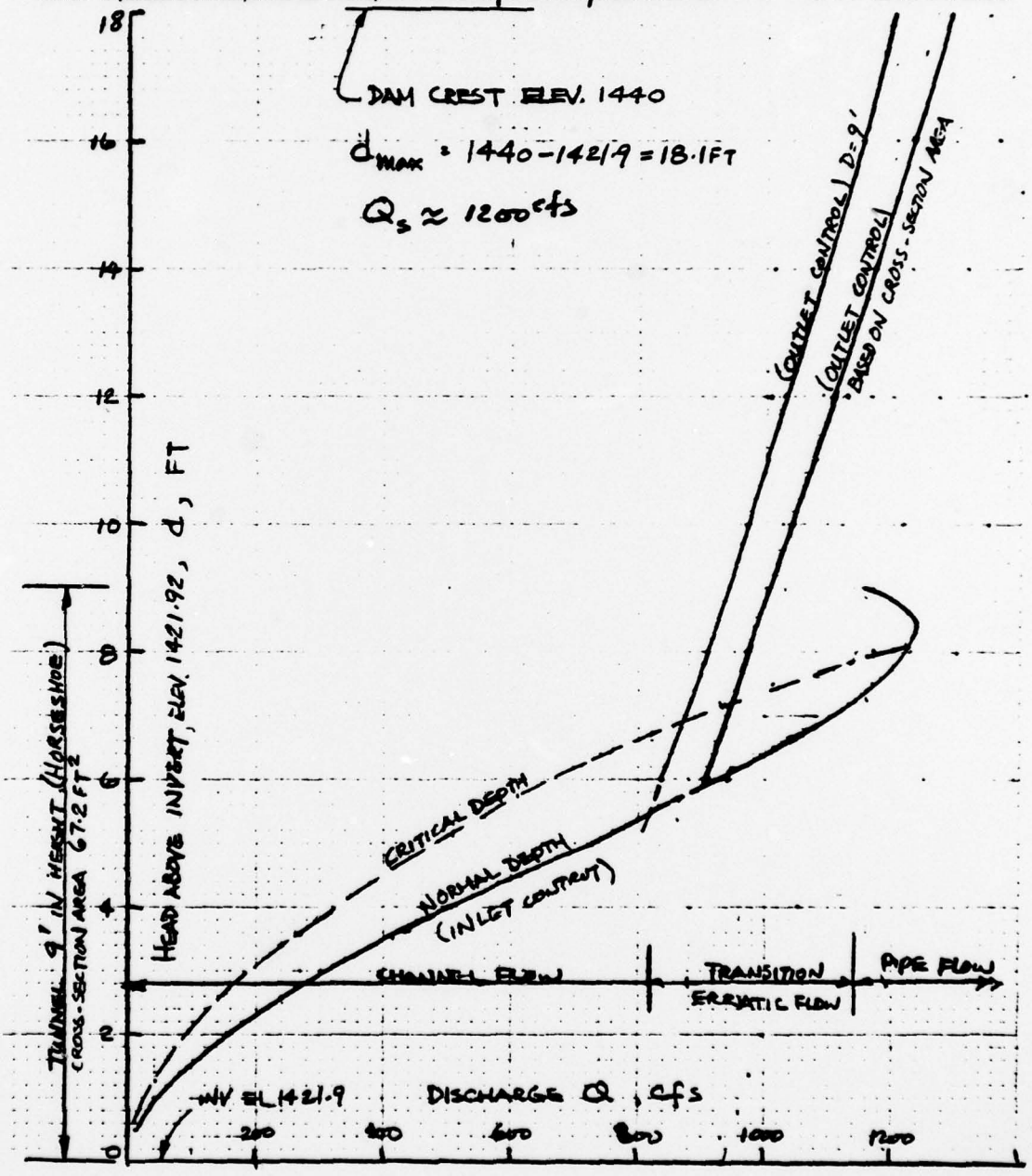
By WJC Date 8-24-78 Subject LOWER (KITTANNING) DAM Sheet No. 1 of 1
Chkd. By MG Date 9/11/78 HYDROLOGY & HYDRAULICS Proj. No. 78114



SPILLWAY CHANNEL CAPACITY (ASSUME BROAD CREST WEIR)

$Q = (3.1)(41)(14)^{1.5}$ (DIMENSION: FROM Field measurement)
(See PLAN & Section on P. 9)

$= 6658$ cfs

say 6700 cfs

TOTAL DISCHARGE CAPACITY (SPILLWAY DISCHARGE CHANNEL + TUNNEL)

$= 6700 + 1200$ ← See Page 7

$= 7900$ cfs < 8480 cfs

7900 cfs control

Say $Q_S = 7900$ cfs

Percent of PMF, (ASSUMING UPPER DAM NOT FAILED & TUNNEL FUNCTIONAL)

$= \left(\frac{7900}{24000} + \frac{\approx 0}{14000}\right) 100\%$ (See NOTE 1)

$= 32.9\%$

Say 33% PMF

PERCENT OF PMF (ASSUMING UPPER DAM NOT FAILED & TUNNEL BLOCKED)

$= \left(\frac{6700}{24000} + \frac{0}{14000}\right) 100\%$ (See NOTE 1)

$= 27.9\%$

Say 28% PMF

NOTE: (1) SINCE THE SURCHARGE STORAGE CAPACITY OF THE U/S DAM (70 ac-ft) IS MUCH SMALLER THAN THE VOLUME OF PMF (14000 ac-ft). THE FLOOD STORAGE EFFECT OF U/S RESERVOIR IN REDUCING THE PMF PEAK INFLOW (24000 cfs) IS NEGLECTED.

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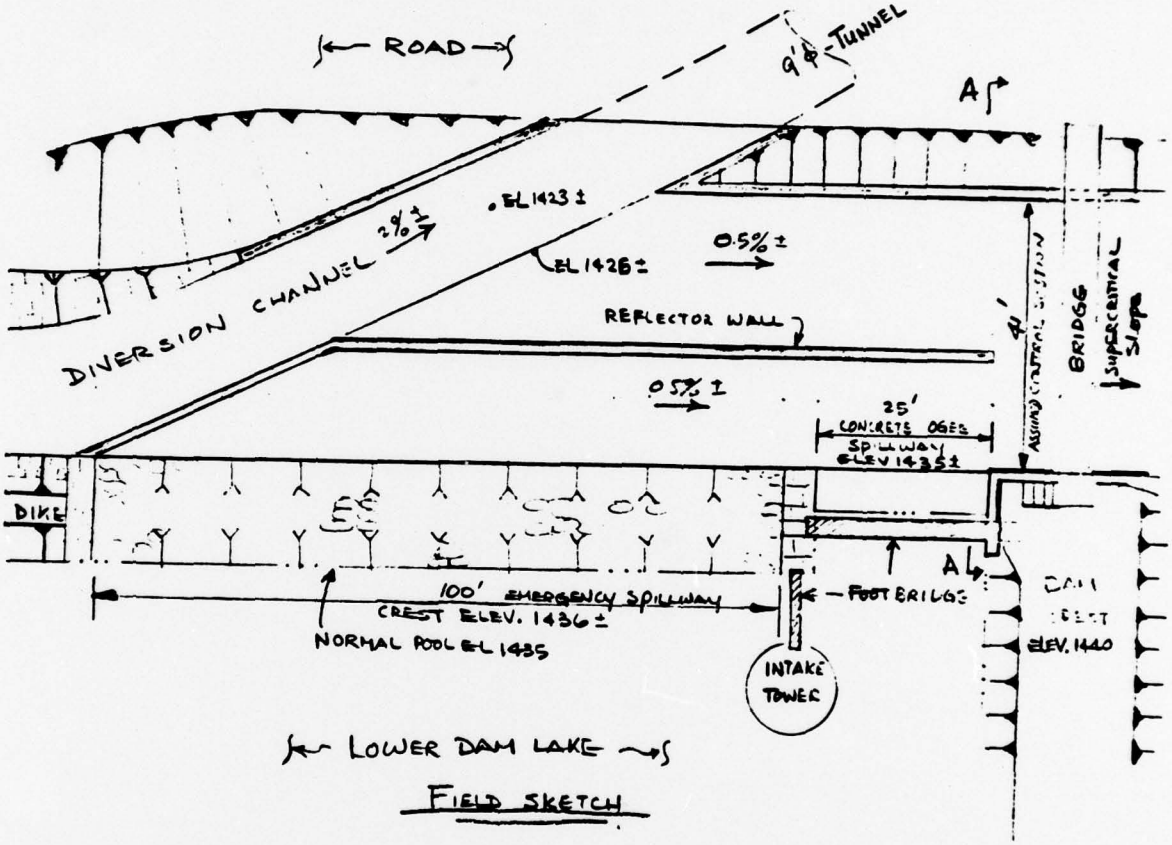
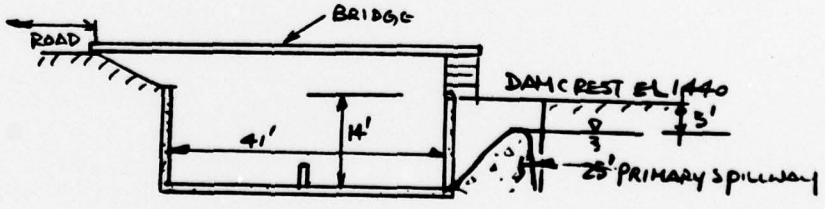
By WTC Date 9-22-78 Subject LOWER (KITTANNING) DAM Sheet No. 9 of 9
Chkd. By BE Date 9-22-78 HYDROLOGY & HYDRAULICS Proj. No. 78-117-23



FIELD SKETCH



SECTION A-A
(DIVERSION CHANNEL SPILLWAY CONTROL SECTION)

APPENDIX E

REGIONAL GEOLOGY

APPENDIX E
REGIONAL GEOLOGY

The Lower Kittanning Dam and reservoir are located on strata of the Devonian Age Catskill Red Beds. The dam is situated in the small valley of Burgoon Run. The flat, wide bottom of the run, as well as the presence of streams at right angles to it, indicate a series of interbedded resistant and less resistant rock layers, with erosion occurring laterally when a more resistant rock layer is encountered. The rock consists of reddish-brown interbedded sandstone and claystone. The sandstone layers are two to four feet thick, hard and contain a joint spacing on the order of three or more feet. The interbedded claystone ranges in thickness from a few inches to several feet and is highly fractured. This "pencil fracturing" forms rock fragments resembling pencils approximately 1/8 inch in diameter and 1/4 to 1/2 inch long.

The beds strike N20E to N30E with a dip of 15 to 20 degrees to the northwest. The joints are nearly vertical and trend approximately N60W, N40W and N30E.

The north slope of the reservoir is moderately steep, while the south slope is very gentle. The slope is hummocky and no rock outcrops were observed. The terrain has characteristics of landslide terrain, although no evidence of recent activity was observed.